SenseLink™ QM 2.2

Multivariate Fault Detection

User Manual

MKS Instruments, Inc.
Control & Information Technology Products Group

70 Rio Robles Dr.
San Jose, CA 95134

Office: 408-750-2919
Fax: 408-750-2990

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70 Rio Robles Dr.
San Jose, CA 95134

Preface

About this addendum

This addendum is designed to serve as a guideline to the installation, set up, operation, and basic maintenance of the Remote Monitoring Unit (RMU) with the SenseLink™ QM multivariate monitoring application. The information contained within this manual, including product specifications, is subject to change without notice. Please observe all safety precautions and use appropriate procedures when handling the SenseLink™ QM hardware product and its related software.

Technology protected by U.S. patent numbers 7,465,417 and 6,993,404.

Table of Contents

1 General Information

The SenseLink™ QM is a data collection and monitoring device targeted for the injection molding industry. The SenseLink™ QM provides a complete system for injection molding multivariate analysis and real time quality and fault detection. The SenseLink™ QM converts electrical and serial data into an archived, ethernet network available format.

For a complete list of models at the time of this printing, see Appendix.

1.1 Conventions used in this User Manual

 **Warning**	**The WARNING sign denotes a hazard to personnel. It calls attention to a procedure, practice, condition, or the like, which, if not correctly performed or adhered to, could result in injury to personnel.**
 **Caution**	**The CAUTION sign higlights information that is important to the safe operation of the BlueBox, or to the integrity of your files. .**
 **Note**	**THE NOTE SIGN DENOTES IMPORTANT INFORMATION. IT CALLS ATTENTION TO A PROCEDURE, PRACTICE, CONDITION, OR THE LIKE, WHICH IS ESSENTIAL TO HIGHLIGHT.**

On screen buttons or menu items appear in bold and cursive.
Example: Click ***OK*** to save the settings.

Keyboard keys appear in brackets.
Example: [ENTER] and [CTRL]

Pages with additional information about a specific topic are cross-referenced within the text.
Example: (See page xxx)

2 Overview

The SenseLink™ QM provides a comprehensive system for modeling a process in real-time, providing predictive results which predict the quality of the part immediately upon being processed. The system resides in parallel with the process controller, minimizing any impact on the existing process.

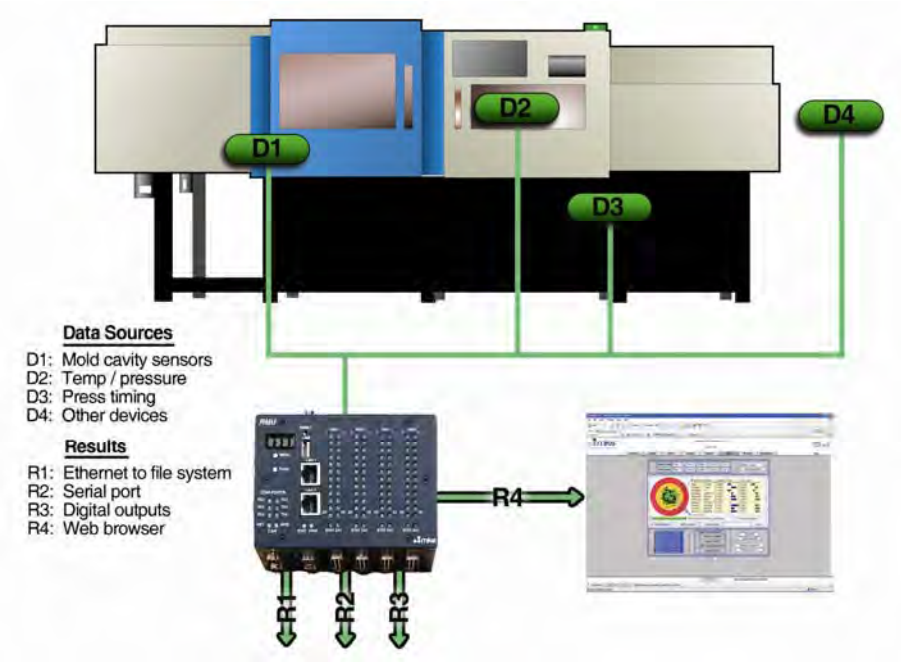


Figure 1 Connection to Injection Molding Machine

The SenseLink™ QM technology detects process deviations in real time and makes an accept or reject decision based on multivariate statistics. This multivariate analysis provides a contribution chart with information describing the root cause or interactions that contributed to the rejection of that suspect part.

2.1 Theory of Operation

The SenseLink™ QM provides complete data acquisition and modeling functionality, for determining process results in real-time, all contained in a single unit with no additional software required.

Setup

a) SenseLink is initially used as a general purpose data acquisition system, where the system connects to the key process signals of the molding machine and calculates the most important features of each signal.

b) A Design of Experiment (DOE) is run to gather process data and to induce process variation. The DOE limits should be designed so that all molded parts are acceptable.

c) A multivariate model is then created within the SenseLink QM, from the DOE, which captures the acceptable operating process window of the specific product. As an option, this model can also be created and edited, outside of the SenseLink QM, using SIMCA P software from Umetrics which offers data and variable modification capabilities along with extensive data analysis.

d) Each new molded cycle is then compared to the multivariate model, where an accept or reject decision is made.

e) Validation experiments are then run to refine the alarm limits of the model and to ensure 100% quality assurance.

Data Acquisition
The system connects to all process variables via analog, digital, serial, or Ethernet based devices. It collects data at a user defined rate, and publishes data to the modeling engine and archive database.

Multi-Variate Analysis (MVA)
The SenseLink™ QM creates a model using data from the DOE or from some historical data set that resulted in 100% acceptable parts. Any new parts are then compared to this known "good" model, and results such as T^2, DModX, and contributions are determined. The results are then returned to the control engine.

Control Engine
Receives the results from the MVA and determines whether the last process is "passed" or "rejected". Logic is then enacted based upon this determination, where the rejected product is automatically removed from the process via a conveyor belt, robot, etc.

SenseLink QM
An s/w application running on the SenseLink™ QM hardware provides the functionality for all data acquisition, control, and user interface (UI). The Linux PC acts as a data storage server and MVA host creating a complete single unit implementation of MVA control.

2.2 Process Variables

The SenseLink™ QM connects to existing sensors, from the process, including screw position, pressure, and temperatures along with digital signals such as mold close, filling, packing, and plasticating to determine the different states of the molding process. Additional inputs such as mold cavity sensors, thermolator temps, hot runner temps, dryer temps, etc. can also be added.

2.2.1 Digital Inputs

SenseLink QM requires information about the current process states. The digital signals provide the system with the ability to calculate important process characteristics during each of the process states. The digital inputs also define the processing window for data analysis.

Table 1 Digital Inputs for Injection Molding Process

ID	Description	Unit	Further information
DI1	**Mold Close**	24V	Mold clamped state, mold open signal can alternatively be used
DI2	**Fill**	24V	Process state where cavity is filling with injection speed
DI3	**Hold**	24V	Process state where cavity is packing/holding with pressure
DI4	**Plastication**	24V	Process state where screw is rotating/extruding to build up shot

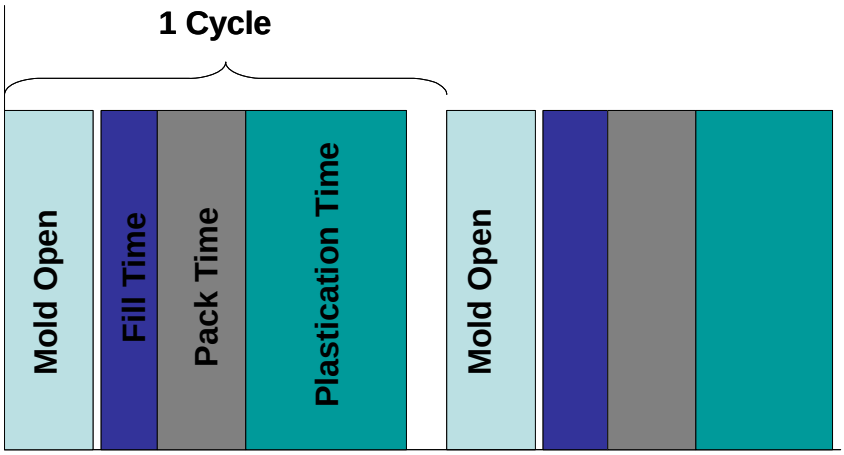


Figure 2 Injection Molding Digital Process States

2.2.2 Analog Inputs

The analog inputs provide the system data for analysis. Multiple important process features are calculated from each analog input.

Table 2 Analog Inputs for Injection Molding Process

ID	Analog Variables	Units	Description
AI1	**Nozzle Temp**	°C	Temp measure at barrel nozzle
AI2	**Barrel Zone 1 Temp**	°C	Barrel temp measured in zone 1
AI3	**Barrel Zone 2 Temp**	°C	Barrel temp measured in zone 2
AI4	**Barrel Zone 3 Temp**	°C	Barrel temp measured in zone 3
AI5	**Injection Pressure**	MPa	Hydraulic or plastic pressure
AI6	**Screw Position**	mm	Axial displacement of screw
AI7	Screw Velocity	mm/s	Velocity of axial movement of screw
AI8	Clamp Force	Tons	Tonnage to clamp mold halves
AI9	Screw Rotational Speed	RPM	Screw rotational speed during screw recovery
AI10	Cavity Pressure	MPa	Pressure measured in mold cavity
AI11	Cavity Temp	°C	Temp measured in mold cavity
AI12	Barrel Temp Zones	°C	Any additional barrel temp zones
AI13	Hot Runner Temps	°C	Any manifold or tip temperatures

2.3 Process DOE

The requirements of the DOE are to teach SenseLink the processing window, to induce process variation, and to develop process data relationships based on the various combinations of process inputs.

Table 3 Injection Molding Sample DOE

Run	Transfer Position	Injection Velocity	Pack Pressure	Screw RPM	Barrel Temp	Mold Temp	Cooling Time	Hold Time
1	-1	-1	1	1	-1	-1	1	1
2	1	1	-1	1	-1	-1	-1	-1
3	-1	1	1	-1	-1	1	-1	-1
4	1	-1	-1	-1	-1	1	1	1
5	0	0	0	0	0	0	0	0
6	-1	1	-1	-1	1	-1	1	1
7	1	-1	1	-1	1	-1	-1	-1
8	-1	-1	-1	1	1	1	-1	-1
9	1	1	1	1	1	1	1	1

The DOE design space should be carefully designed by the customer or by MKS based on the customers needs. The DOE should be created to emulate long term process variation while still creating 100% good parts. The average of high and low limits should be the optimum process and at least one DOE run should be done at that median factor level. The SenseLink creates models based on the DOE, so the design and time put into the DOE and measuring the parts is of utmost importance.

3 Quick-Start Installation

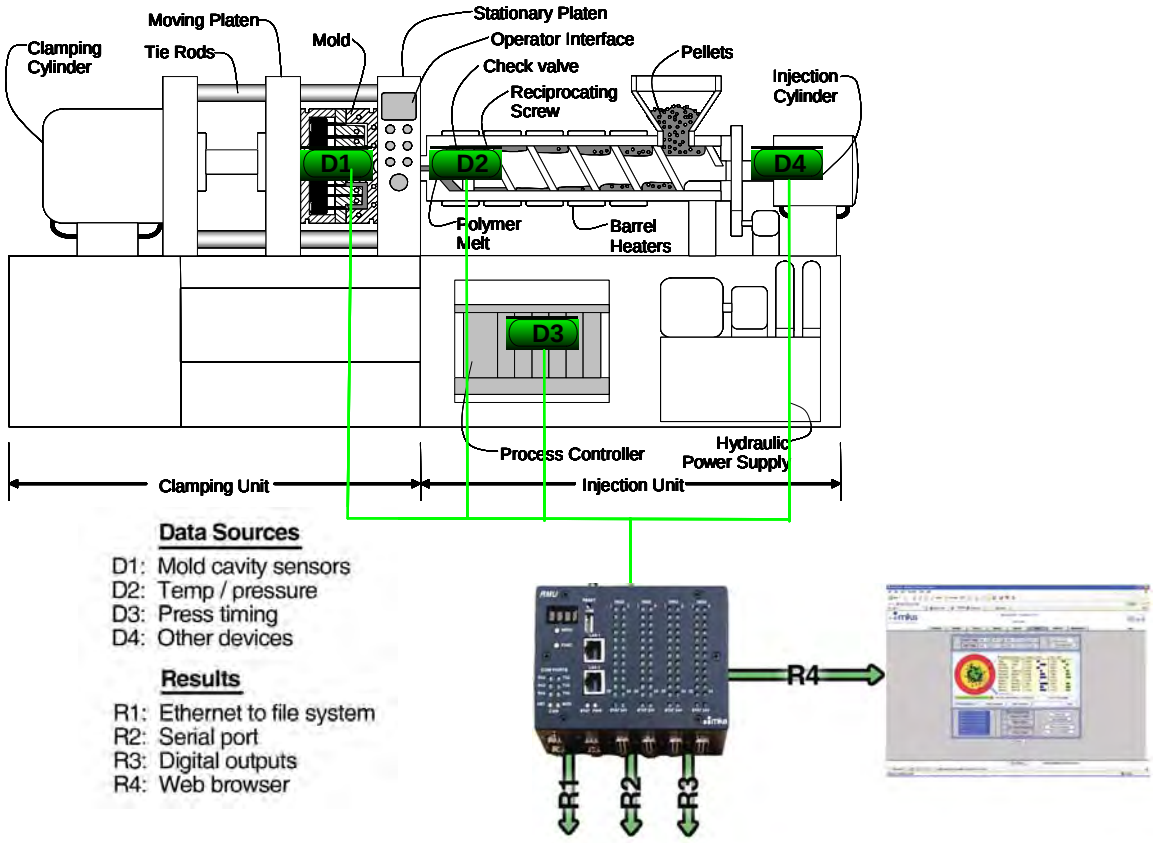


Figure 3 Injection Molding Machine/SenseLink Interconnect

SenseLink hardware resides on the tool and may contain the following connections:

- Power, 24VDC at 1 amp
- Analog inputs (up to 16), specified as either Differential or Single-Ended, 14 bit
- Digital inputs, active low, opto-coupler input
- Digital output, contact closure, normally open, 1A
- Serial RS232/485, 2 channels, for data acquisition from intelligent devices
- Ethernet, 10BT, RJ45 for data acquisition from intelligent devices and link to SenseLink network

4 Quick-Start for MVA Control

4.1 Introduction

Mount and connect the SenseLink to the system.

Once the SenseLink is connected electrically, the following configuration will occur:

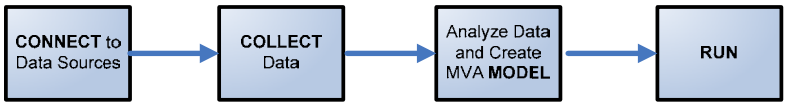


Figure 4 SenseLink Setup

4.2 Connect

1. Power up SenseLink by attaching power connector and plugging in 24VDC power supply to 110VAC.

2. Attach Ethernet cable to SenseLink LAN 2 and your PC.

3. Modify your network TCP/IP settings to match the following (PC IP address should have same base IP address as LAN 2 port which is displayed on unit screen):
   PC IP Address: 192.168.1.1
   PC Netmask: 255.255.255.0

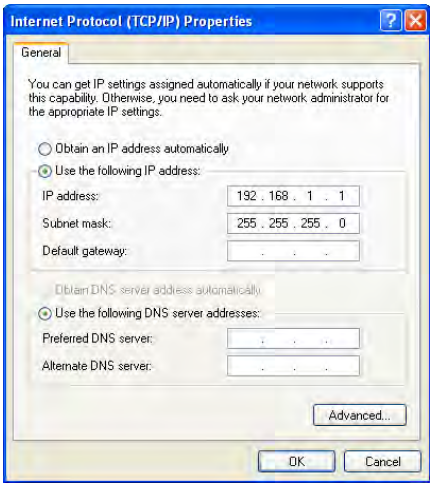


Figure 5 TC/IP Properties

Note

Custom SenseLink™ QM solutions may have a configuration requiring different default settings. For custom applications refer to the addendum for specific default settings

4. Open up your web browser and enter the address of the LAN 2 port 192.168.1.2. You will then be prompted for a password. Enter “user” for both username and password. You will see the main SenseLink™ QM configuration page. There is slight delay as the unit transfers items to your local browser. A recent update of Java may be required to run the SenseLink applets.

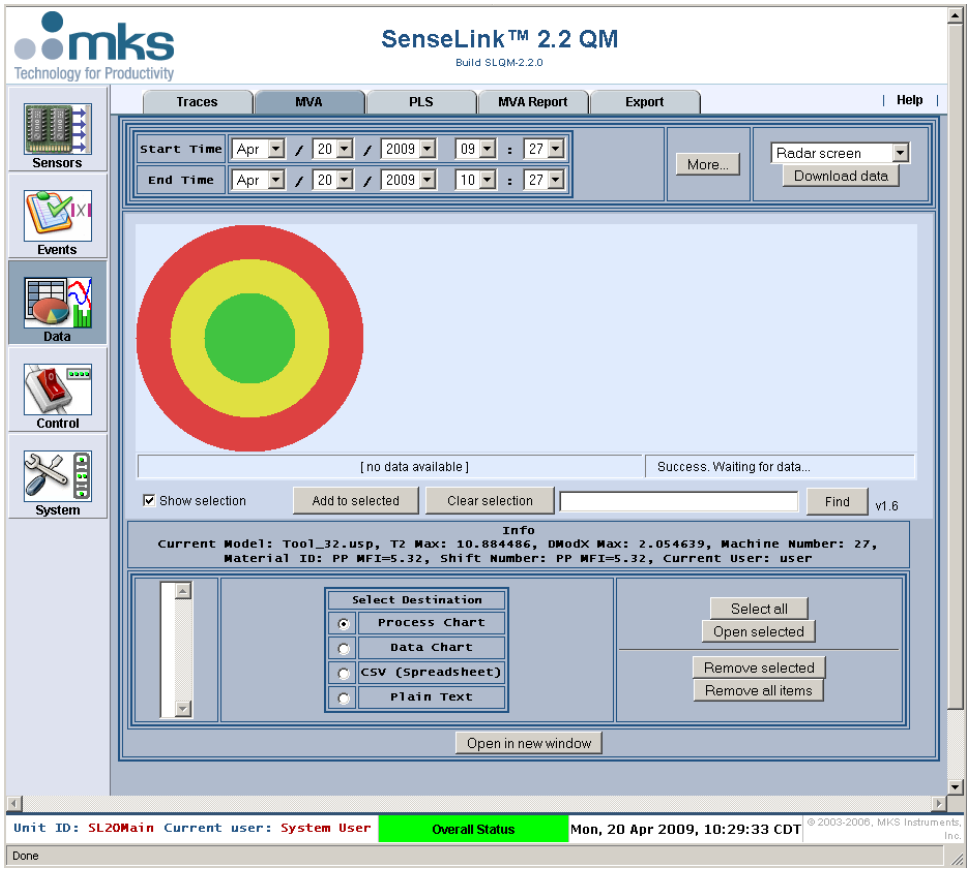


Figure 6 SenseLink Main Page

5. Click on the ***Traces*** tab, which will show you the current, running data collection plans. Collection plan DataCP is by default configured with only virtuals for model creation and Test is configured with raw data.

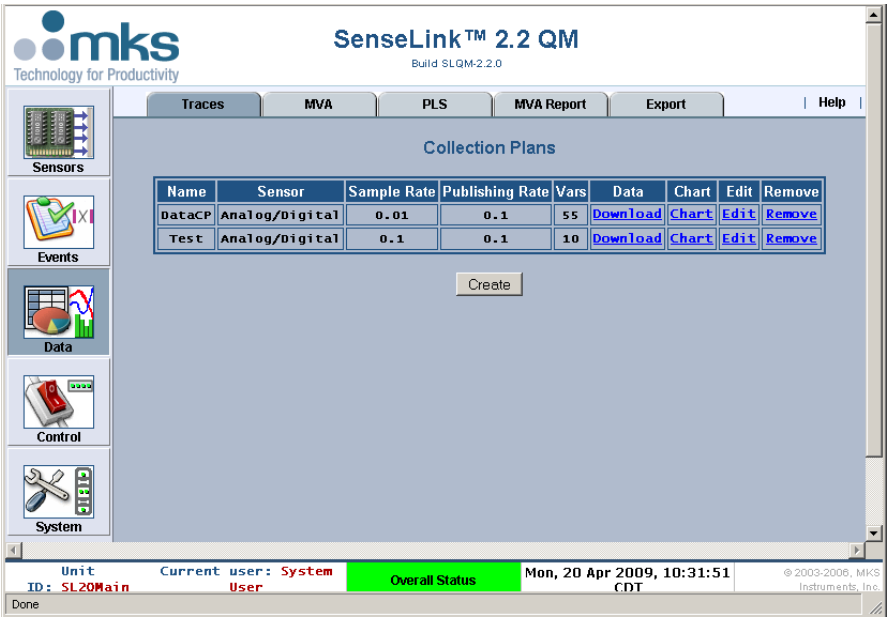


Figure 7 Traces Main Page

6. Select ***Chart*** for collection plan "**Test**" and a new browser window will open up. Raw data that has been collected will appear for graphical analysis. There are many data viewing options available using this graph.

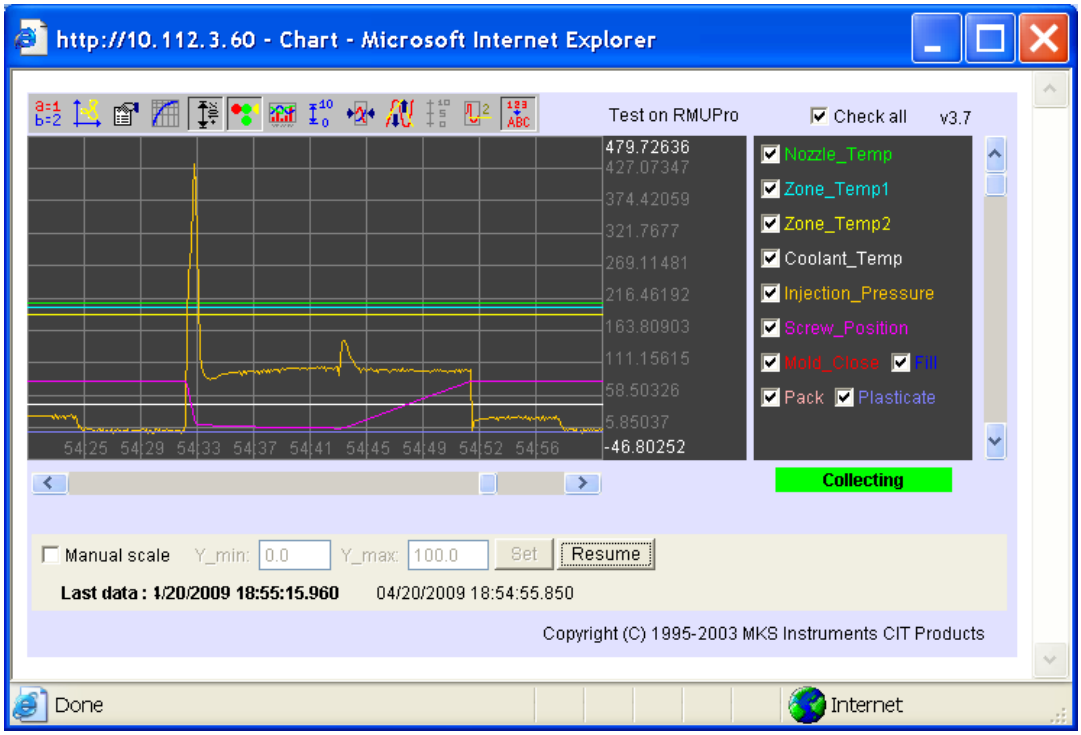


Figure 8 Traces Chart

7. Transport the collected raw data to your PC. Under the same ***Traces*** tab, in the Download Data column, select ***Download***. A page will open to provide options on the timeframe of data you would like to access.

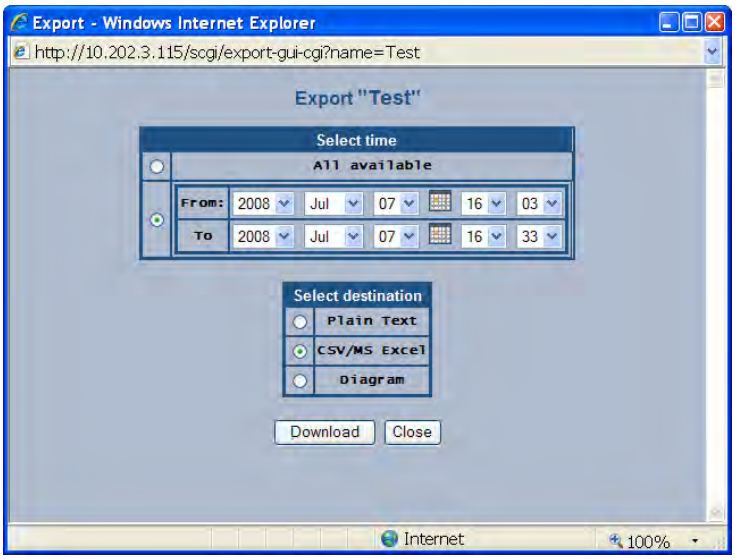


Figure 9 Exporting Collection Plan

8. Click on ***Download*** and the data will be sent to your PC for plain text, MS-Excel format, or graphical viewing.

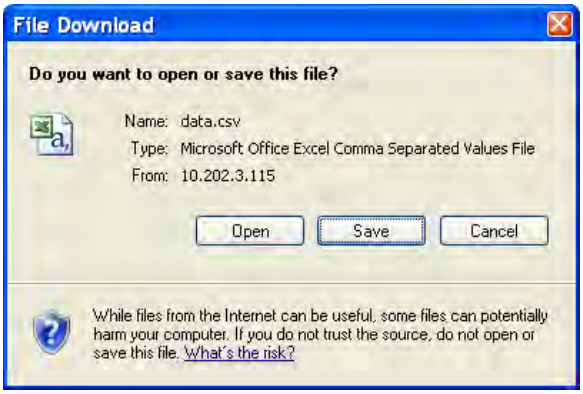
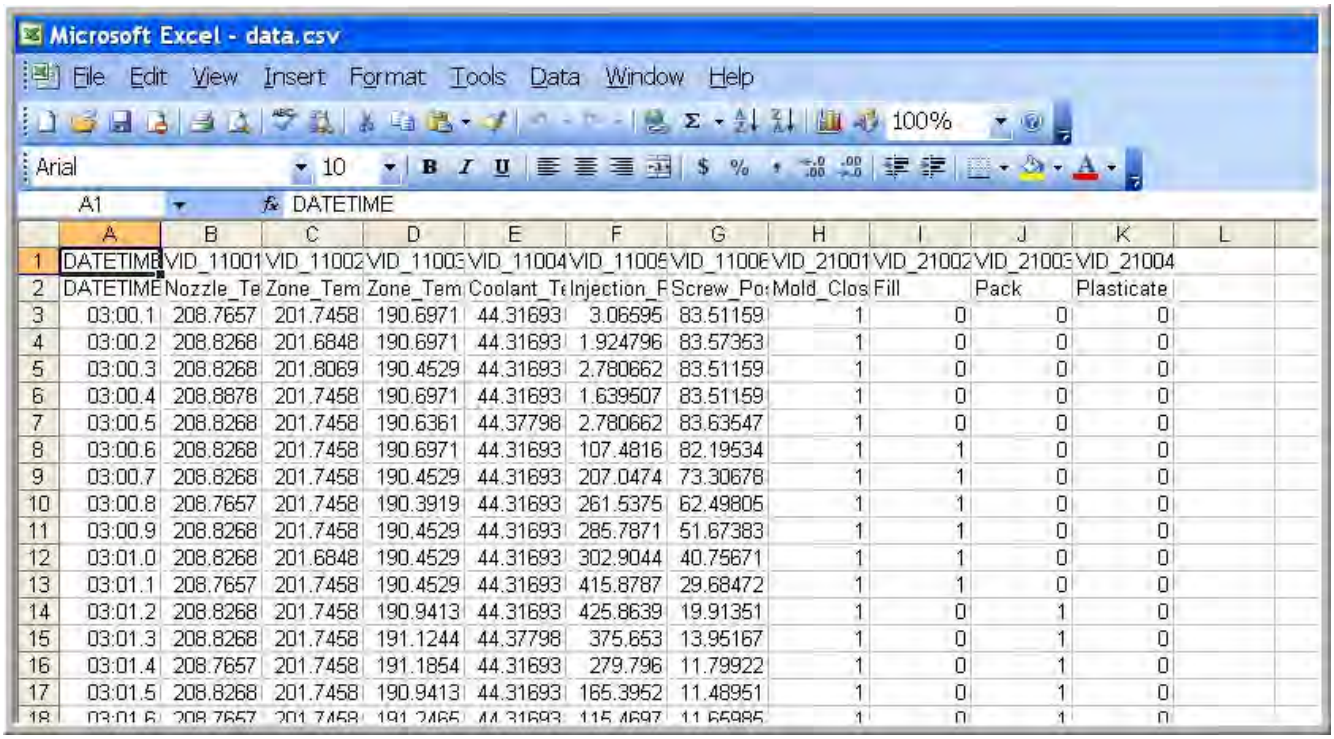


Figure 10 Downloading Collection Plan



	A	B	C	D	E	F	G	H	I	J	K	L
1	DATETIME	VID_11001	VID_11002	VID_11003	VID_11004	VID_11005	VID_11006	VID_21001	VID_21002	VID_21003	VID_21004	
2	DATETIME	Nozzle_Te	Zone_Tem	Zone_Tem	Coolant_Te	Injection_P	Screw_Po:	Mold_Clos	Fill	Pack	Plasticate	
3	03:00.1	208.7657	201.7458	190.6971	44.31693	3.06595	83.51159	1	0	0	0	
4	03:00.2	208.8268	201.6848	190.6971	44.31693	1.924796	83.57353	1	0	0	0	
5	03:00.3	208.8268	201.8069	190.4529	44.31693	2.780662	83.51159	1	0	0	0	
6	03:00.4	208.8878	201.7458	190.6971	44.31693	1.639507	83.51159	1	0	0	0	
7	03:00.5	208.8268	201.7458	190.6361	44.37798	2.780662	83.63547	1	0	0	0	
8	03:00.6	208.8268	201.7458	190.6971	44.31693	107.4816	82.19534	1	1	0	0	
9	03:00.7	208.8268	201.7458	190.4529	44.31693	207.0474	73.30678	1	1	0	0	
10	03:00.8	208.7657	201.7458	190.3919	44.31693	261.5375	62.49805	1	1	0	0	
11	03:00.9	208.8268	201.7458	190.4529	44.31693	285.7871	51.67383	1	1	0	0	
12	03:01.0	208.8268	201.6848	190.4529	44.31693	302.9044	40.75671	1	1	0	0	
13	03:01.1	208.7657	201.7458	190.4529	44.31693	415.8787	29.68472	1	1	0	0	
14	03:01.2	208.8268	201.7458	190.9413	44.31693	425.8639	19.91351	1	0	1	0	
15	03:01.3	208.8268	201.7458	191.1244	44.37798	375.653	13.95167	1	0	1	0	
16	03:01.4	208.7657	201.7458	191.1854	44.31693	279.796	11.79922	1	0	1	0	
17	03:01.5	208.8268	201.7458	190.9413	44.31693	165.3952	11.48951	1	0	1	0	
18	03:01.6	208.7657	201.7458	191.2466	44.31693	115.4697	11.65985	1	0	1	0	

Figure 11 Downloaded Raw_Data Collection Plan Example

9. Now you are ready to customize the SenseLink™ QM for your applications. The following features can be quickly customized for your application:

   - Scale all values to real units. Also collect min, max, average, derivative, and integral values.
   - Change the frequency of data collection
   - Modify the alarm logic using complex expressions
   - Email based on alarm events
   - Graph and analyze data
   - Change network settings
   - Define a network share for continuous data export and backup

4.3 Customizing Analog Inputs

Select the ***Analog*** tab and choose ***Edit Inputs***.

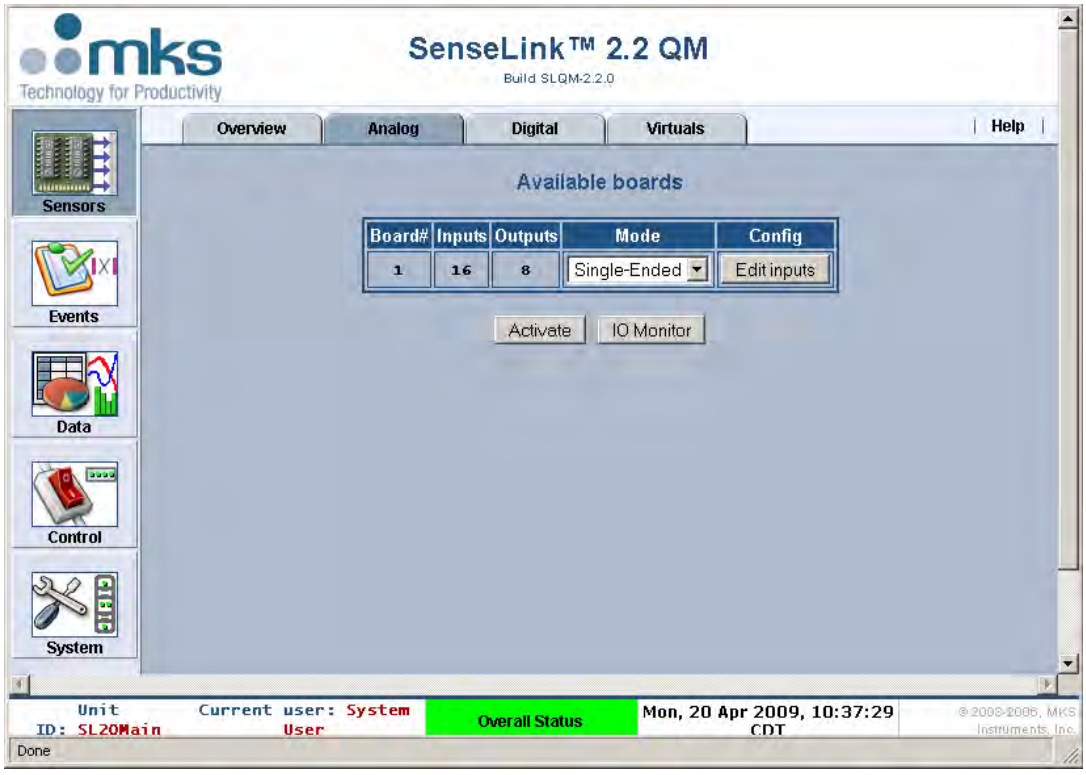


Figure 12 Analog Boards

Edit the input names and scale each signal. Depending on the amount of sensors, multiple analog boards may need to be used. Once all of the names and scaling are entered, select ***Save*** and then select ***Activate*** from the Analog tab.

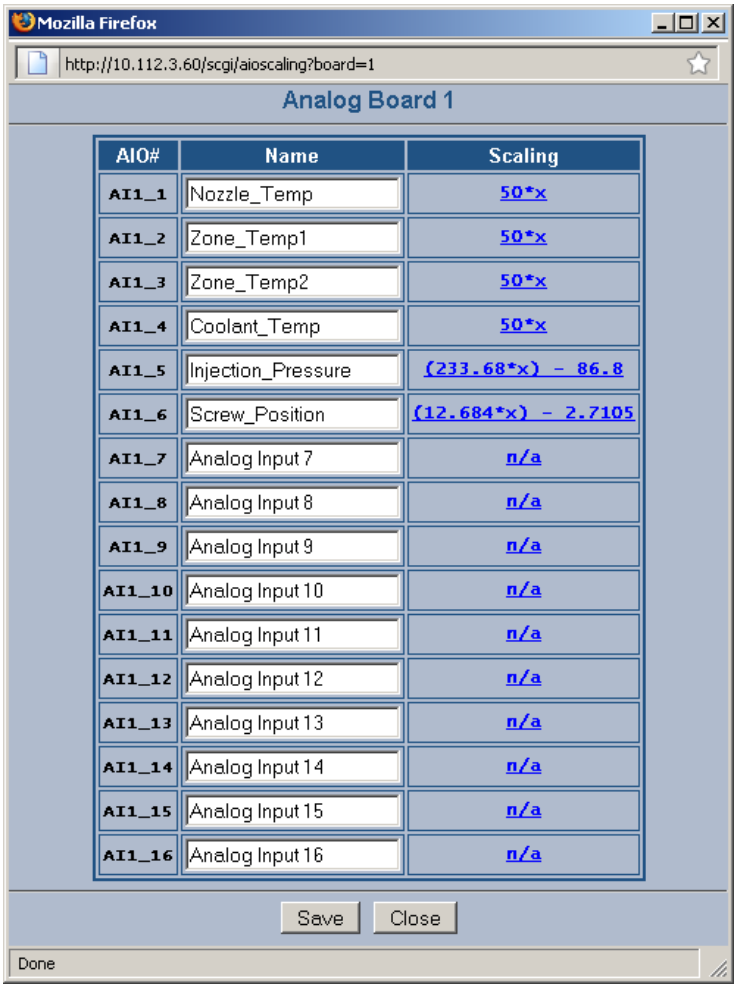


Figure 13 Editing Analog Signals Board 1

Open the ***I/O Monitor*** to make sure each point is reading a correct value by selecting the ***IO Monitor*** button.

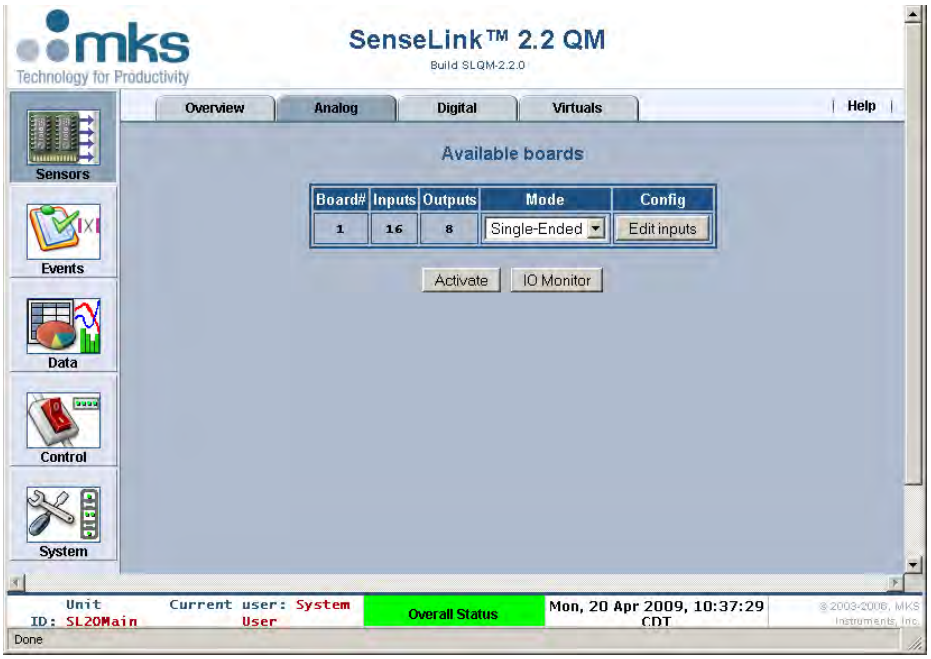


Figure 14 Selecting IO Monitor

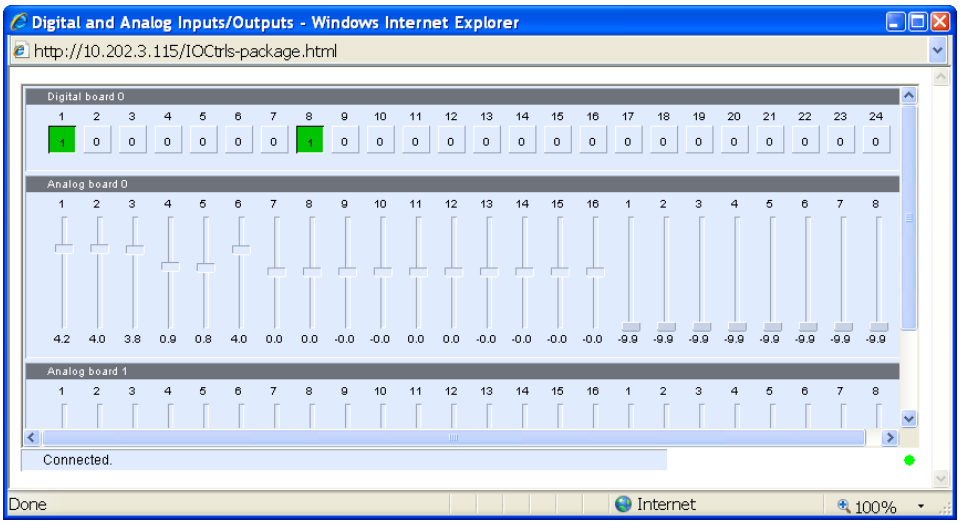


Figure 15 IO Monitor

4.4 Customizing Digital Inputs

Configure each point as in/out and enter the name of the signals by clicking the ***Edit*** button.

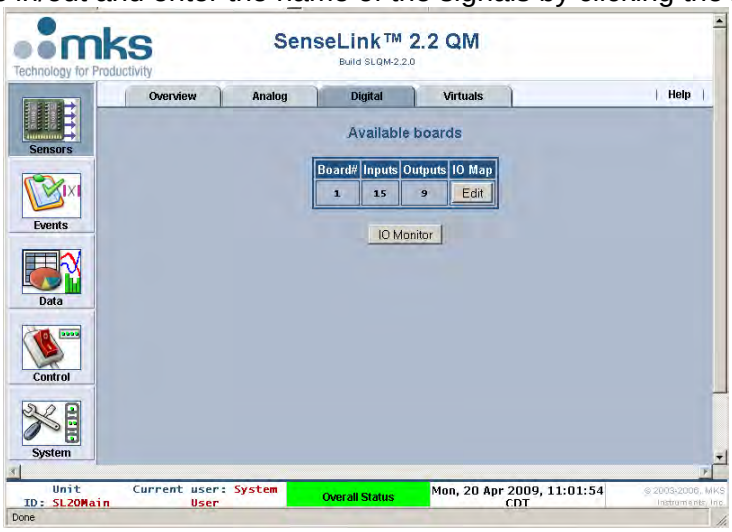


Figure 16 Digital Boards.

Select ***Save*** when complete.

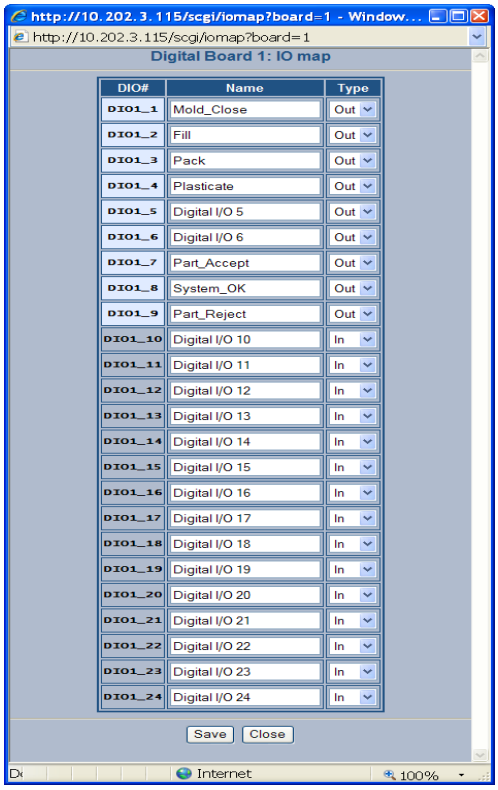


Figure 17 Editing Digital Signals

4.5 Virtuals

Under the ***Virtuals*** tab, data features can be calculated using arithmetic expressions and functions based on the analog and digital process signals. A default set of data features will be provided based on the users available signals. Any new data features can then be easily added by the user.

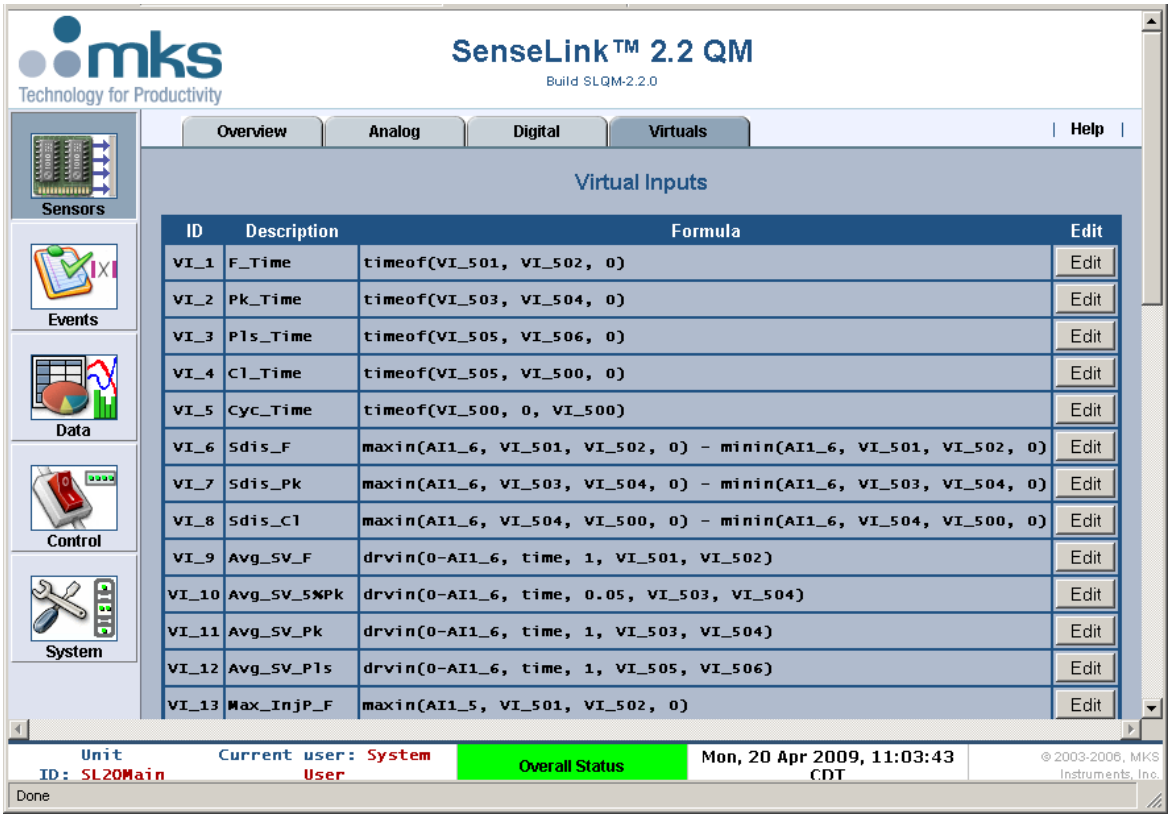


Figure 18 Virtual Inputs

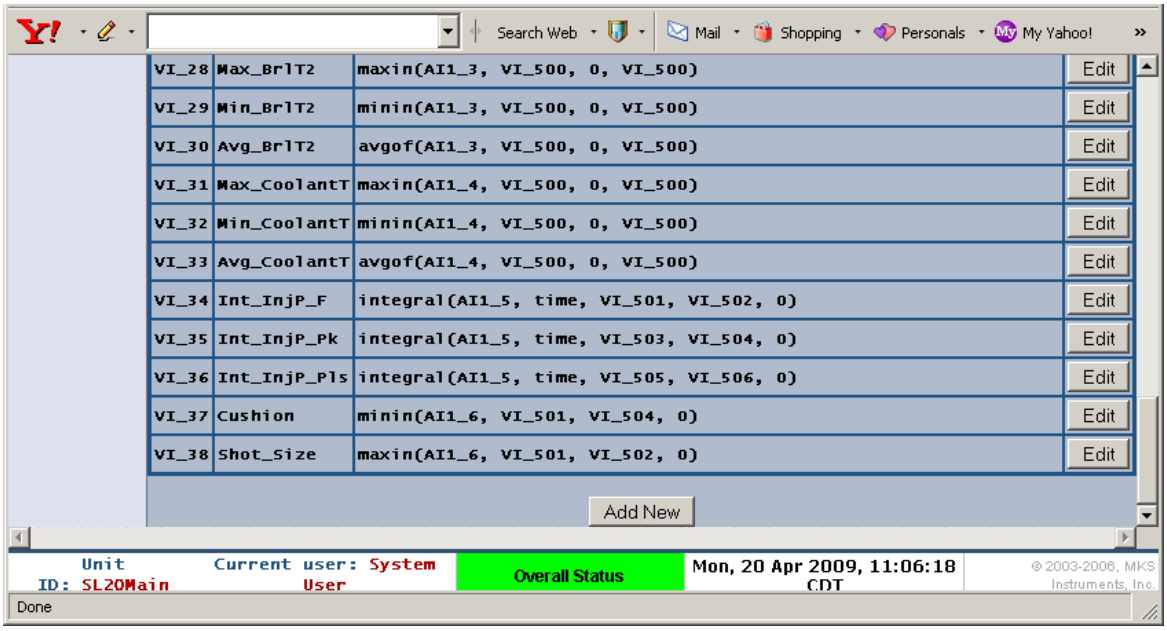


Figure 19 Click Add New to Create New Virtual Signal.

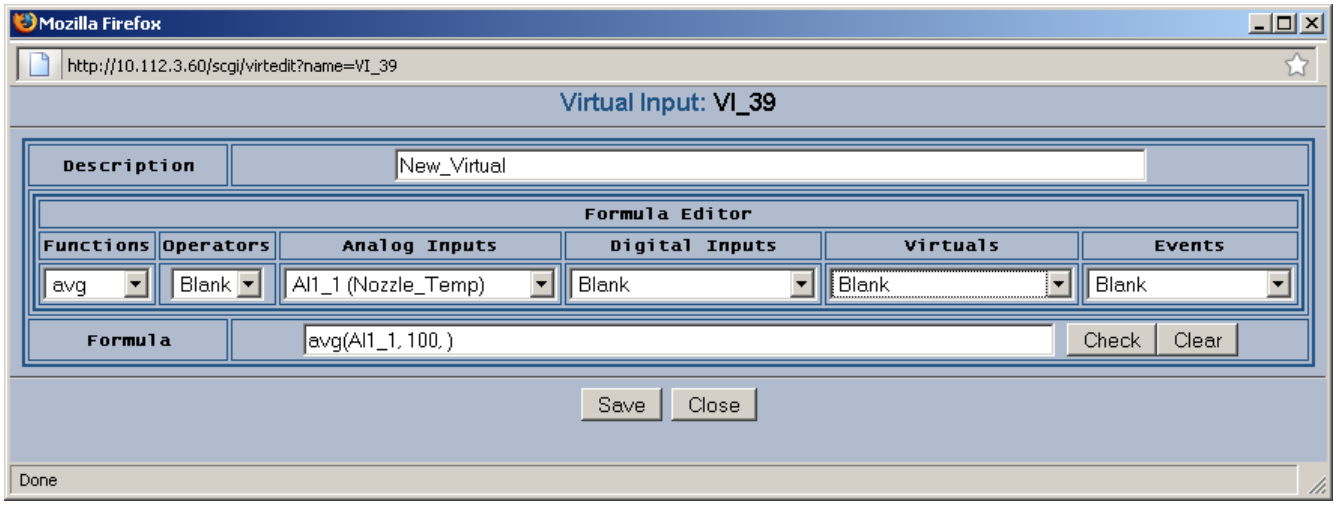


Figure 20 Adding Virtuals

4.6 Events

Under the ***Events*** tab, process states such as process start and end can be created using Boolean expressions. Events can also be used in the virtual calculation to simplify the equations.

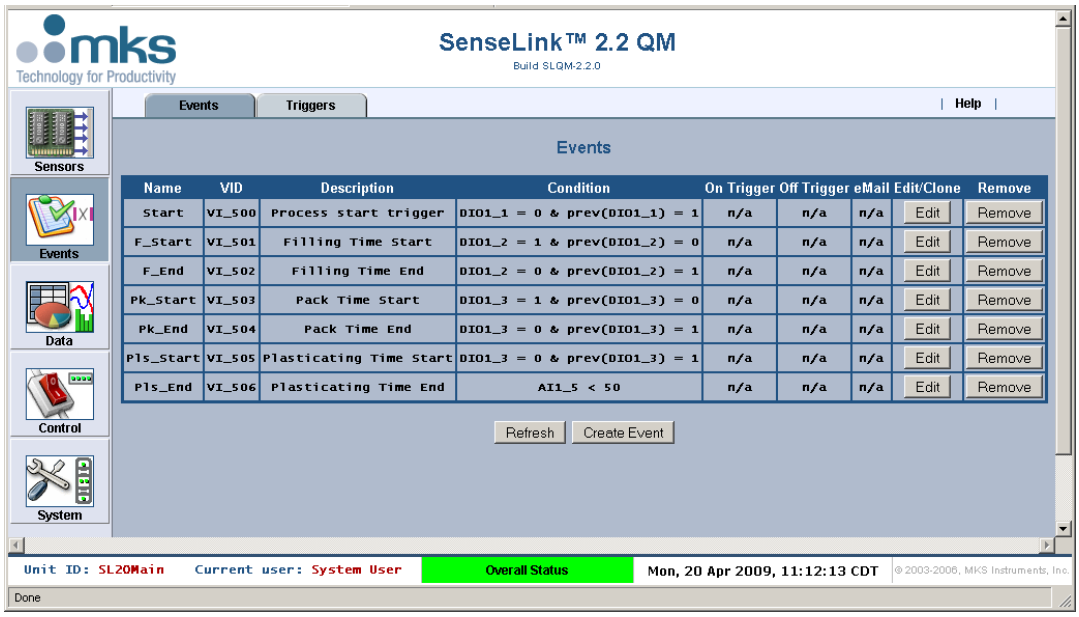


Figure 21 Process Events

Click Edit on an event for that particular event configuration.

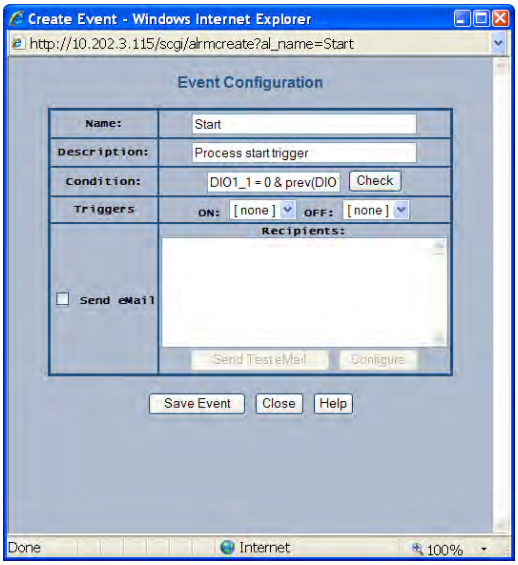


Figure 22 Configuring Events

4.7 Triggers

Create output functions or control sequences that can happen as result of the data analysis. For example, conveyers or robots can be setup to eliminate suspect parts.

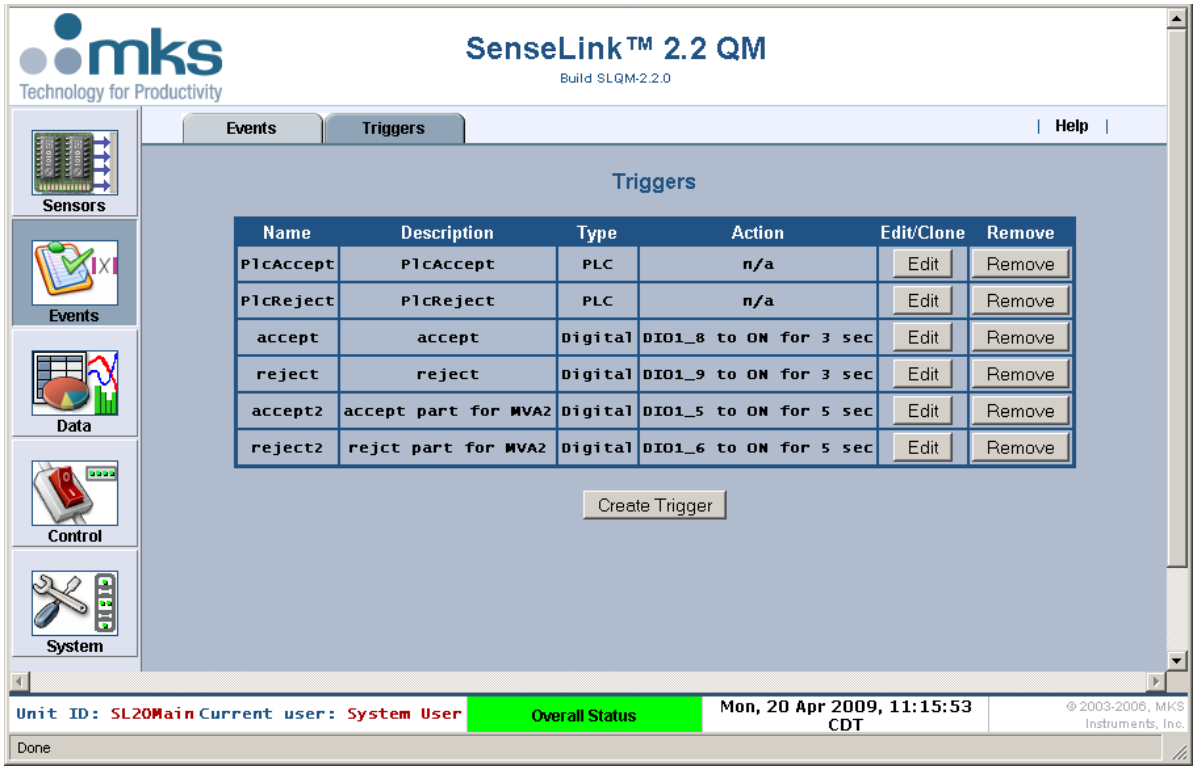


Figure 23 Triggers

New trigger can be created easily by user by clicking on Create Trigger button.

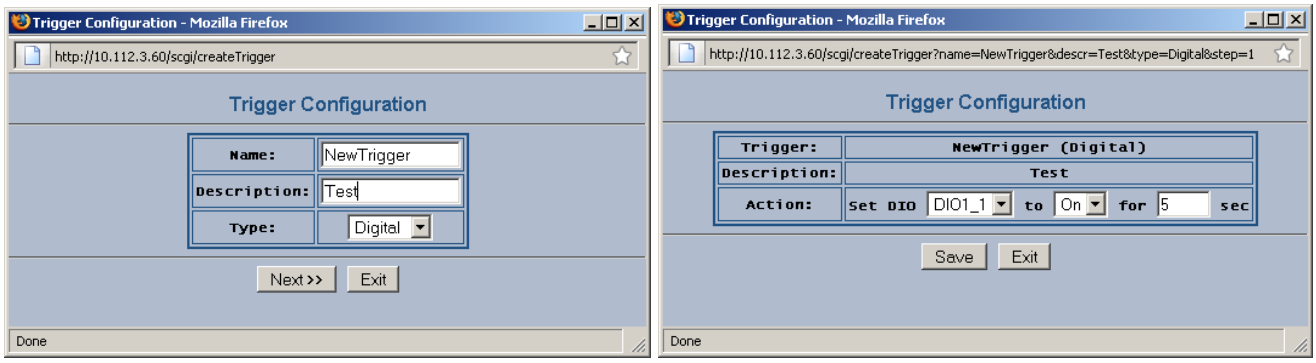


Figure 24 Creating New Trigger

Click Edit on any particular trigger to change its configuration/setting.

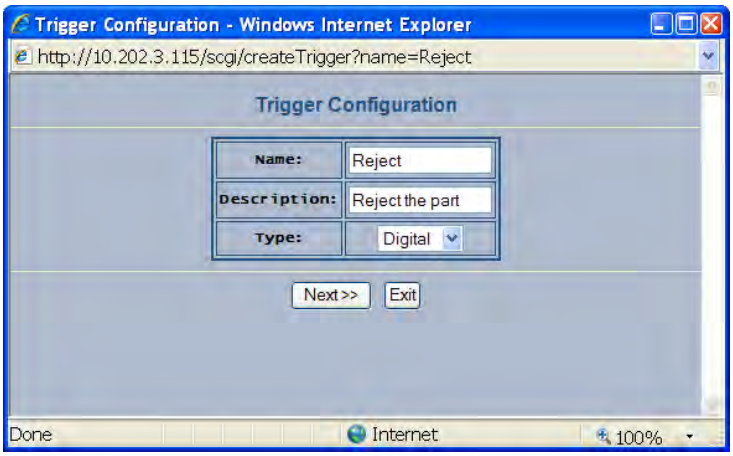


Figure 25 Editing Triggers

4.8 Collect

Under the ***Data/Traces*** tab, collection plans can be created which specify the data to collect, the data sampling rate, and the data publishing rate. By default the ***DataCP*** collection plan is setup as the modeling collection plan with only virtuals selected and the ***Test*** collection plan is setup for viewing of raw analog and digital signals.

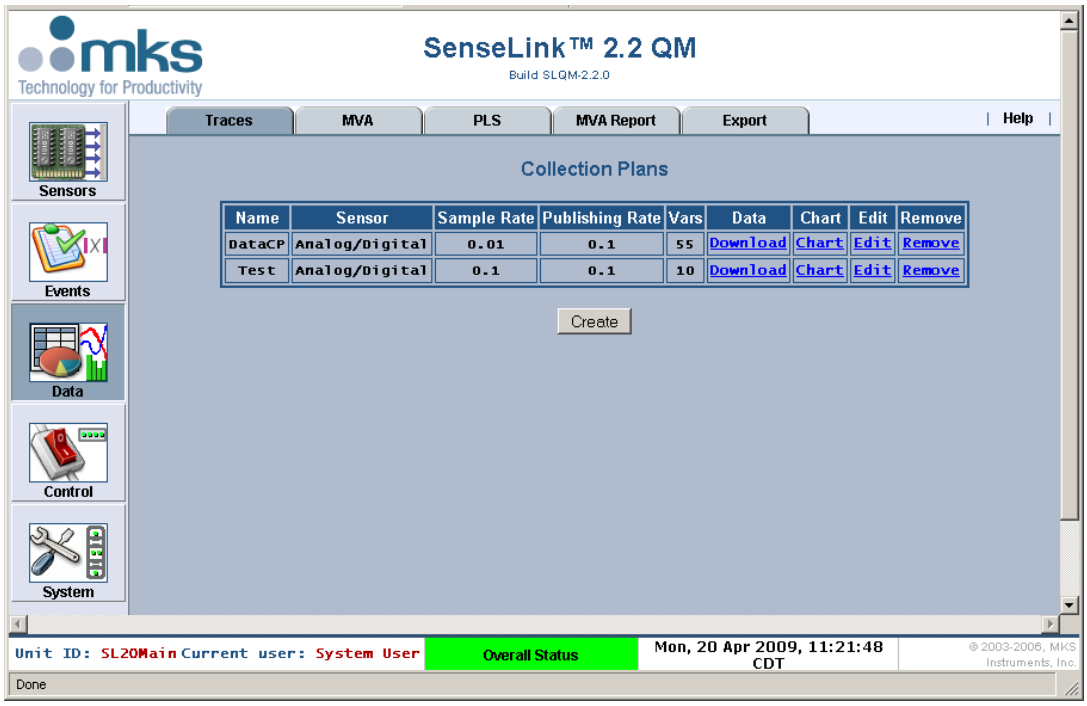


Figure 26 Data Collection Plans

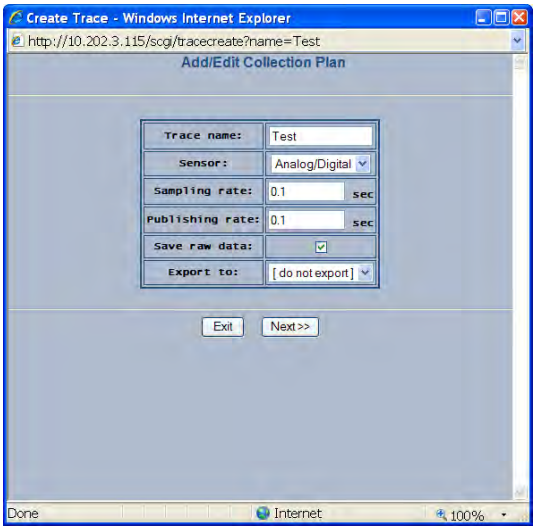


Figure 27 Editing Collection Plans

4.9 Running the DOE

1. Go to the Vertical ***Control*** tab and select the ***MVA Config*** page.
2. Ensure that the **DataCP** collection plan is selected before running the DOE.
3. Also be sure to select the event "**Start**", as it is setup as mold open (cycle start and cycle end) for both Process Start and Process Stop.
4. Select the triggers for Accept and Reject and also for the Health DIO select the System OK, Model, and Parametric Release digital outputs, which by default are DIO1_1, DIO1_3, and DIO1_4 by default respectively.
5. Then select ***Activate*** to put the changes in place.

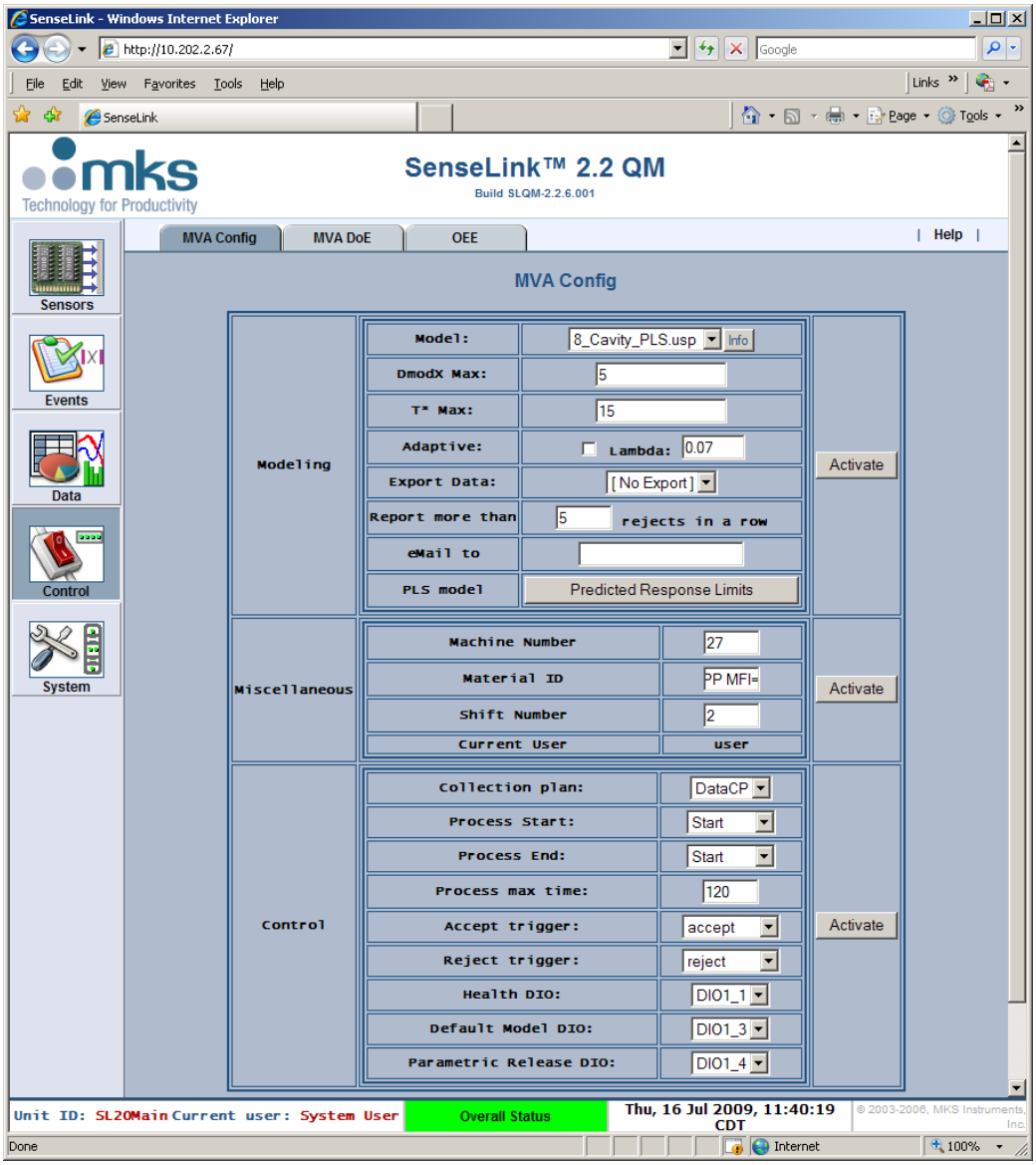


Figure 28 Setting up Data Collection to Run DOE

6. To begin the DOE select the ***MVA DoE*** tab and enter the name of the DOE and the amount of data collection time needed to run the DOE.

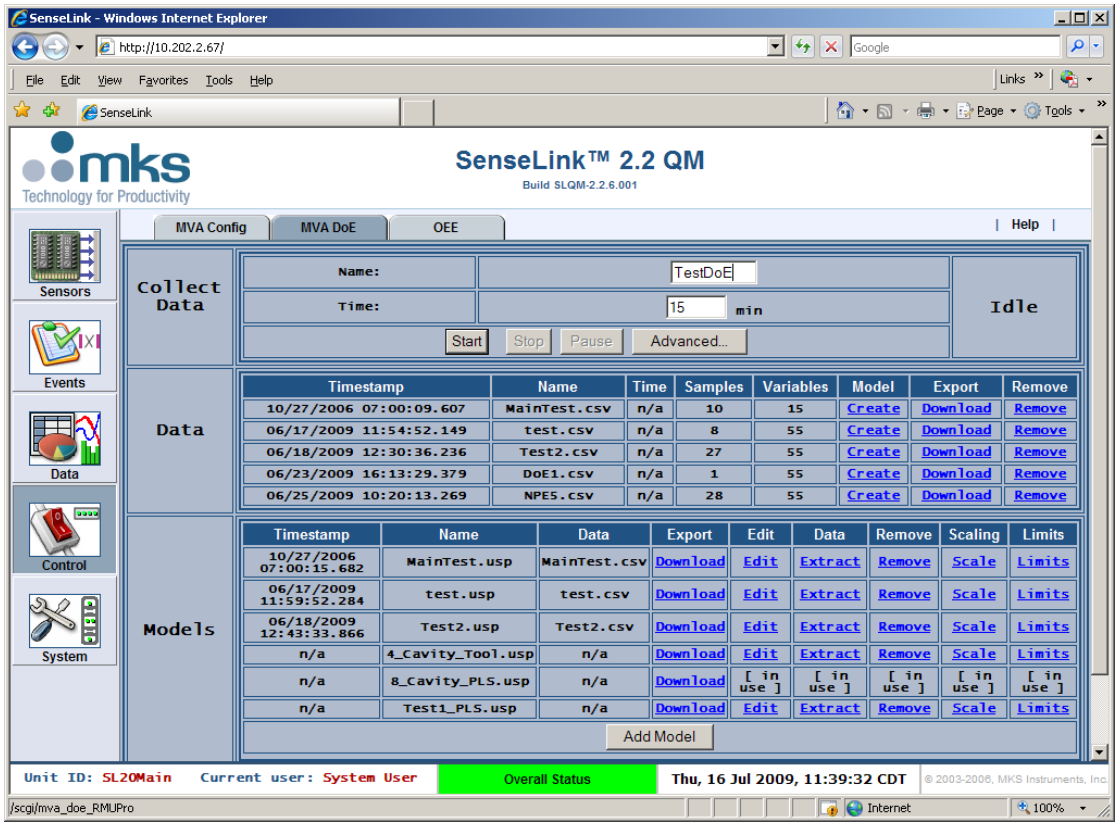


Figure 29 Setting up a DOE

7. Select ***Start***. Data is now being collected which will be used to create the model.

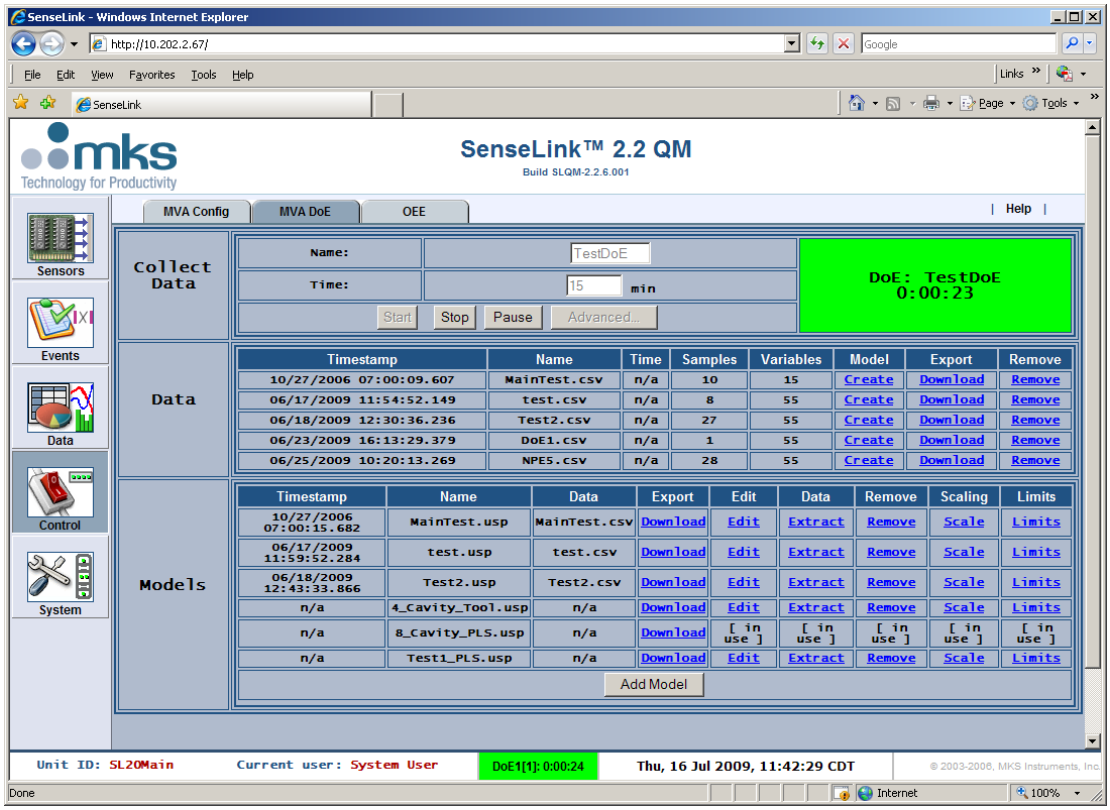


Figure 30 DOE in Progress

8. Selecting ***Pause*** when a process change is needed will pause data collection until the user is ready to start collecting data again, usually once the process has reach steady state.

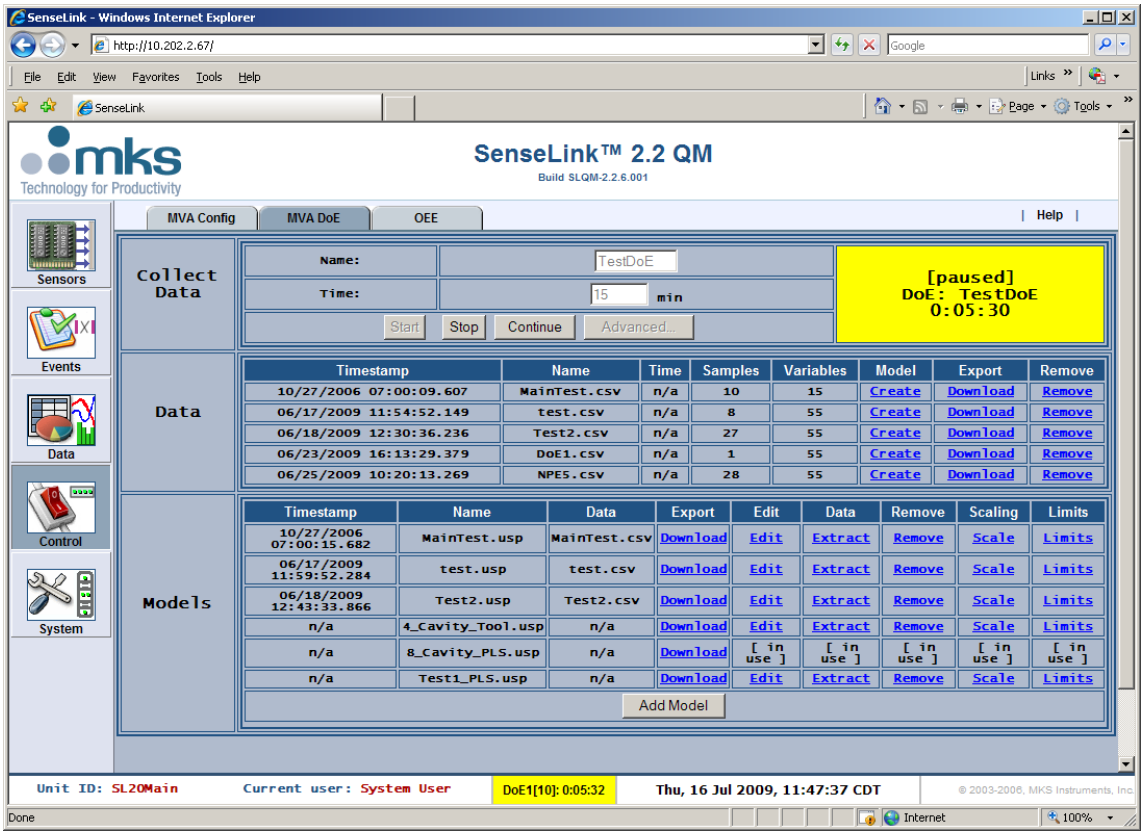


Figure 31 Pausing Data Collection for DOE Run Changes

9. Then select ***Continue*** to start collecting data again. Also, when running a DOE, it is useful to know how many shots have been run so the number of cycles in the DOE are shown at the bottom of the page.

10. Select ***Stop*** to finish the DOE and store the data.

4.10 Creating and Editing Models

Creating a model can either be done offline through SIMCA P+ and uploaded into the SenseLink under the ***MVA DoE*** page or it can be created online within the SenseLink.

4.10.1 Creating Models Offline using SIMCA P+

Once the data from the DOE is stored in the data section shown above, select ***Download*** in the Export column and save the file.

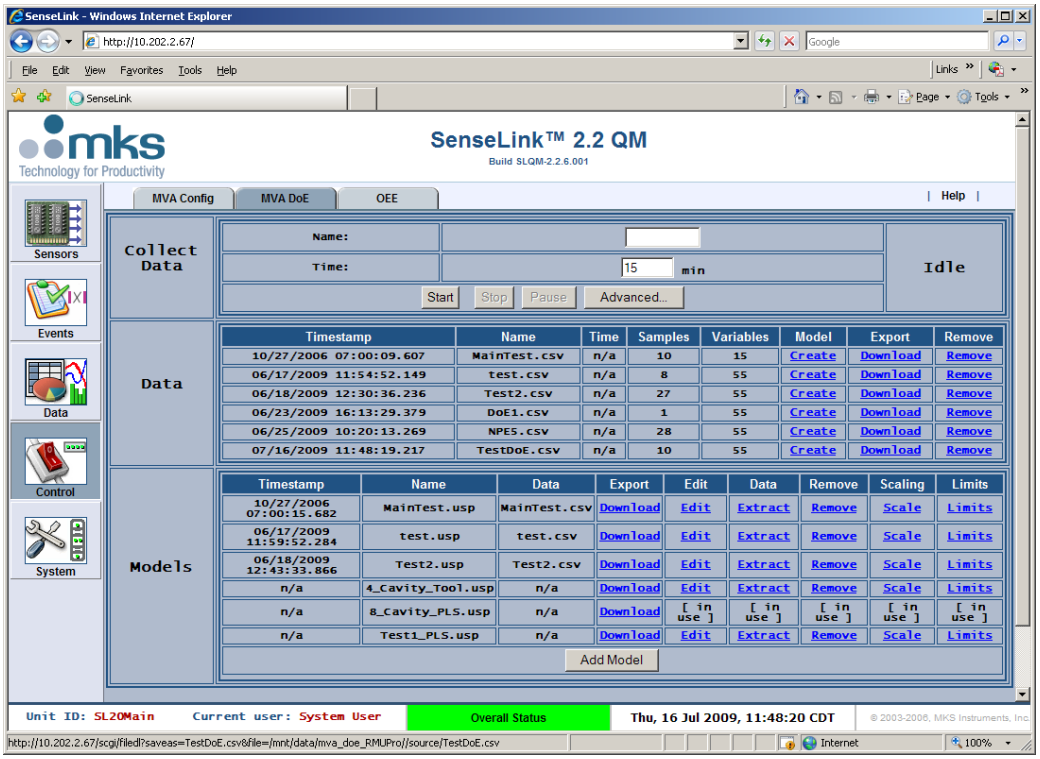


Figure 32 Downloading data from DoE

The file can then be imported into SIMCA P+ for analysis and individual parts or runs can be excluded from the data set if necessary. The data should be analyzed with only X-variables to create a Principal Component Analysis (PCA) model. This model should then be saved as a **.usp** file and can be imported into the SenseLink. Select ***Add Model*** and browse to the saved model file and select ***Upload***. The model is now available for use in the SenseLink QM and will show up in the Models section shown above.

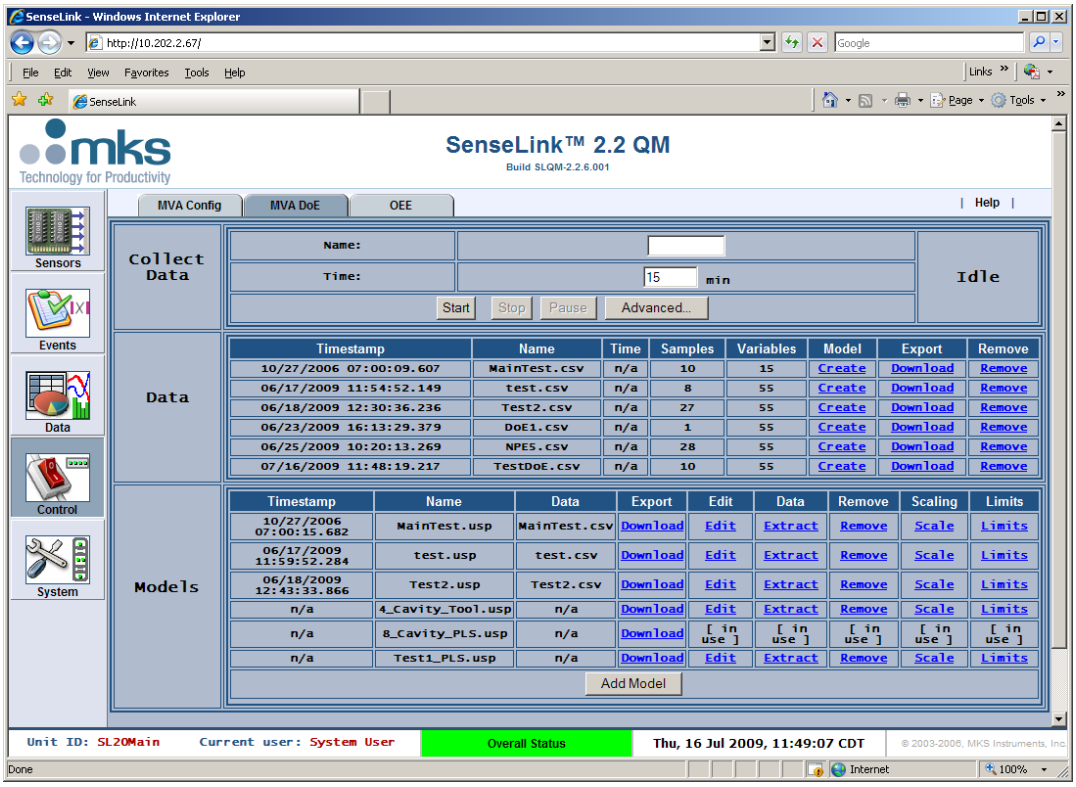


Figure 33 Importing Model from SIMCA P+

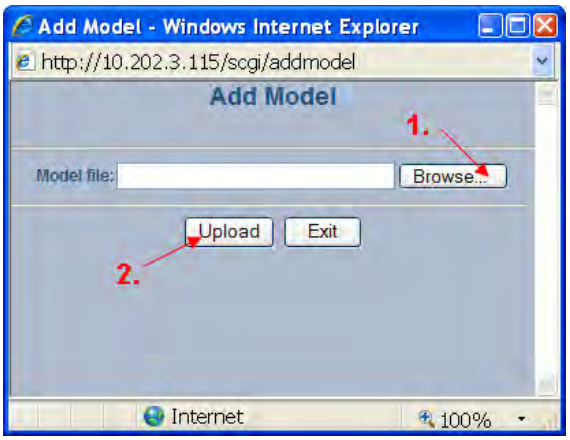


Figure 34 Importing Model – Upload window

4.10.2 Creating Models Online through SenseLink

Once the data from the DOE is stored in the Data section shown below, select ***Create*** to create the model.

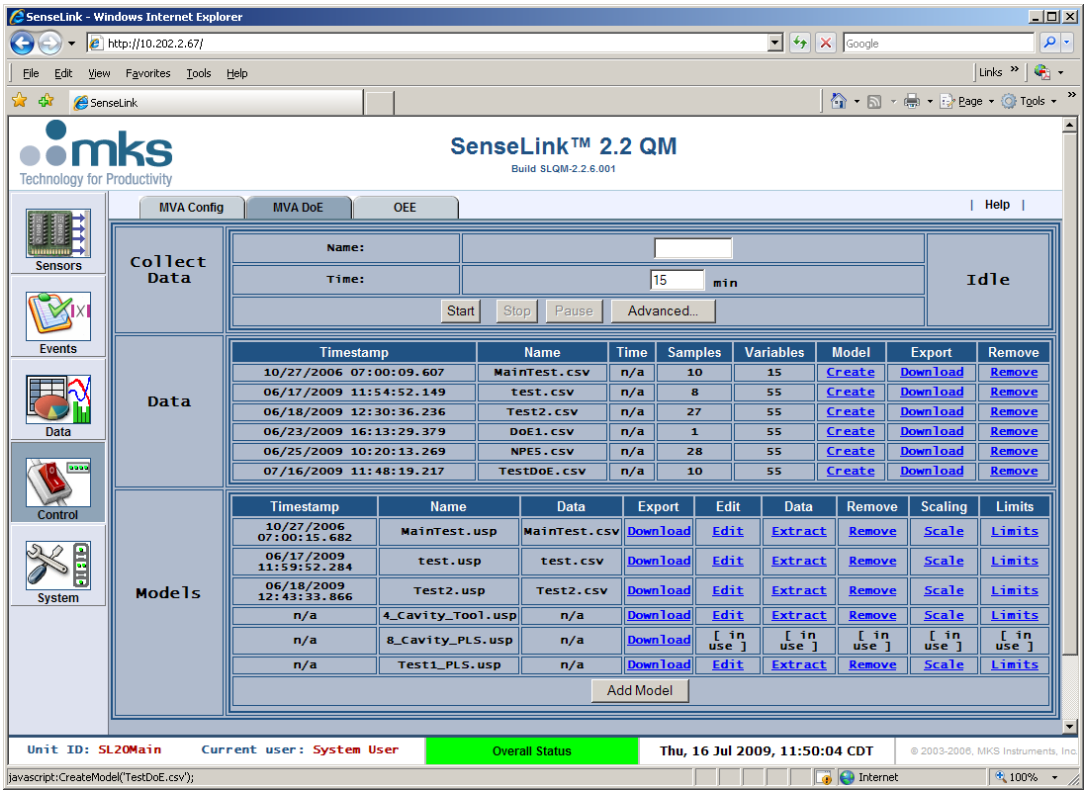


Figure 35 Creating Model online from DoE data

A new window will open; be sure that *Data Features Only* is selected and select ***Create***. Also the type of model building approach can be chosen.

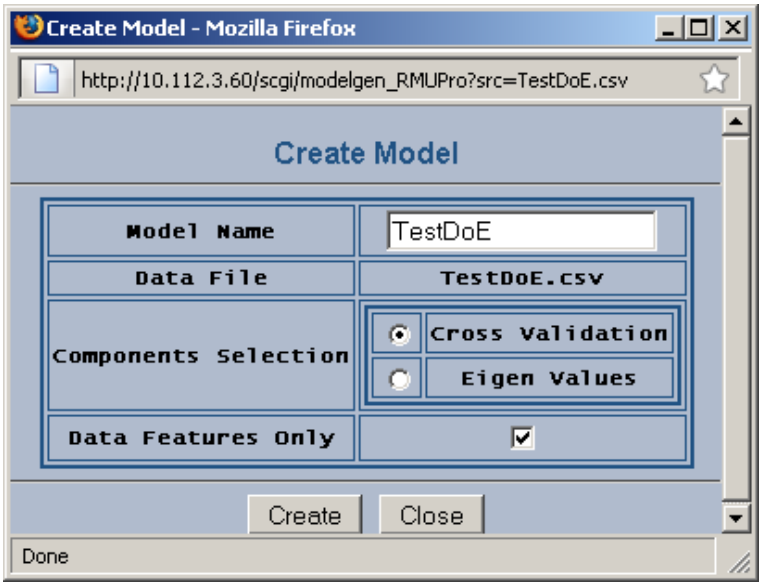


Figure 36 Creating Model Online Through SenseLink

Close when the model is successfully created. The model will then be created and will be displayed in the Models section shown below.

4.10.3 Editing Models

Select ***Edit Model*** to see the first and second component scatter plot and view outliers.

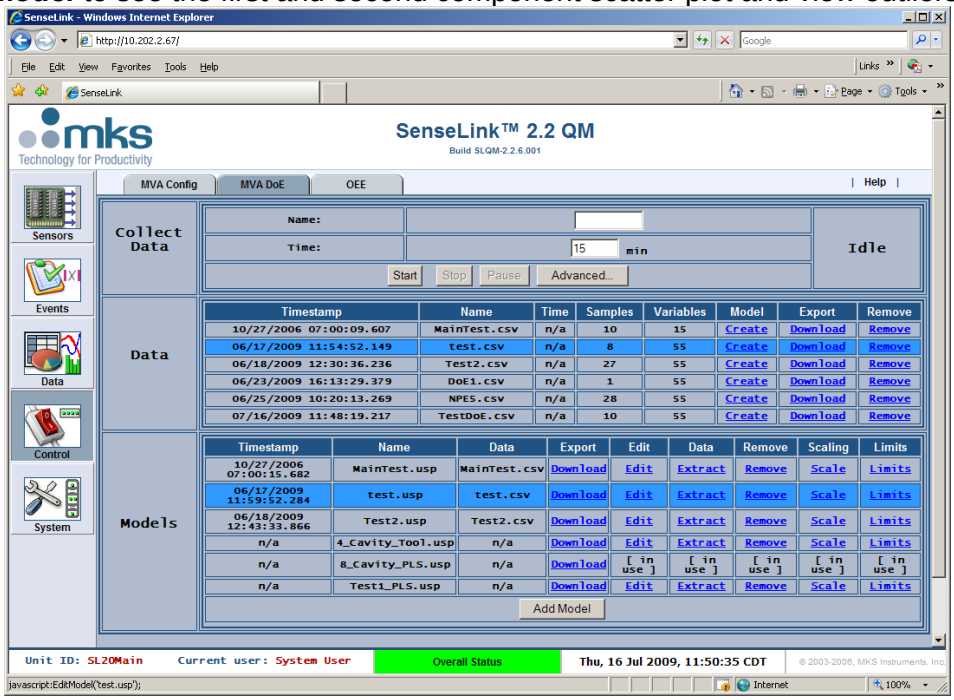


Figure 37 Editing Model Online Through SenseLink

From here you can remove outliers and rebuild the model.

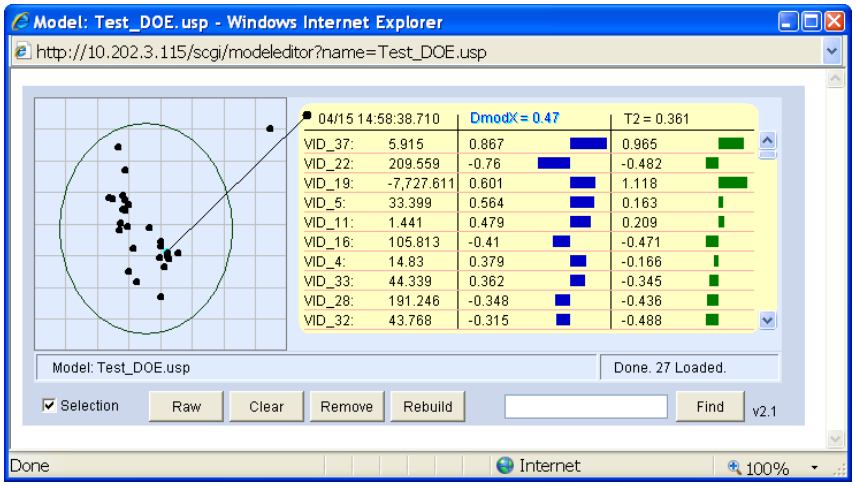


Figure 38 Editing and Rebuilding Model

4.11 Scaling Virtuals

Virtuals can also be scaled by selecting the ***Scale*** link under the Scaling column.

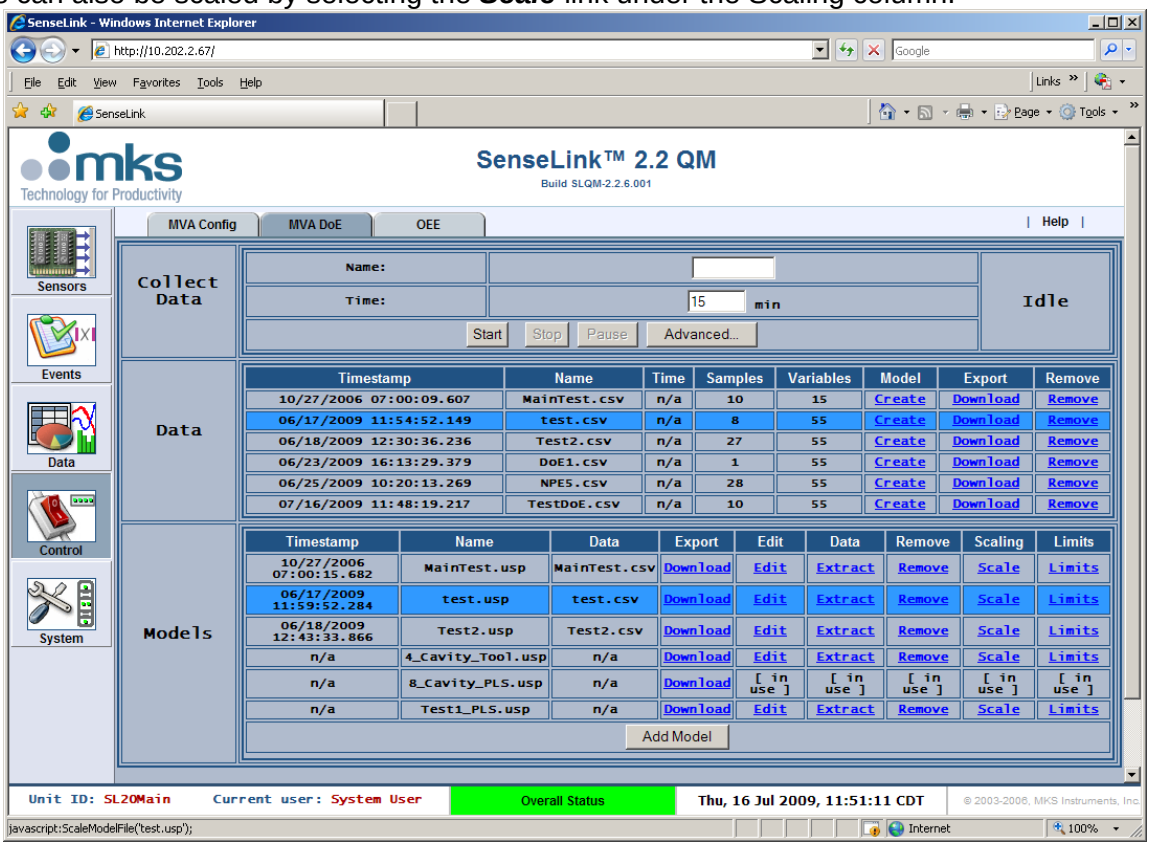


Figure 39 - Scaling Virtuals

Each of the individual virtuals can then be selected and scaled per the variables importance. Scaling Type should be entered and then select the forward arrows to advance to the next screen. Then select ***Done*** to have the model built.

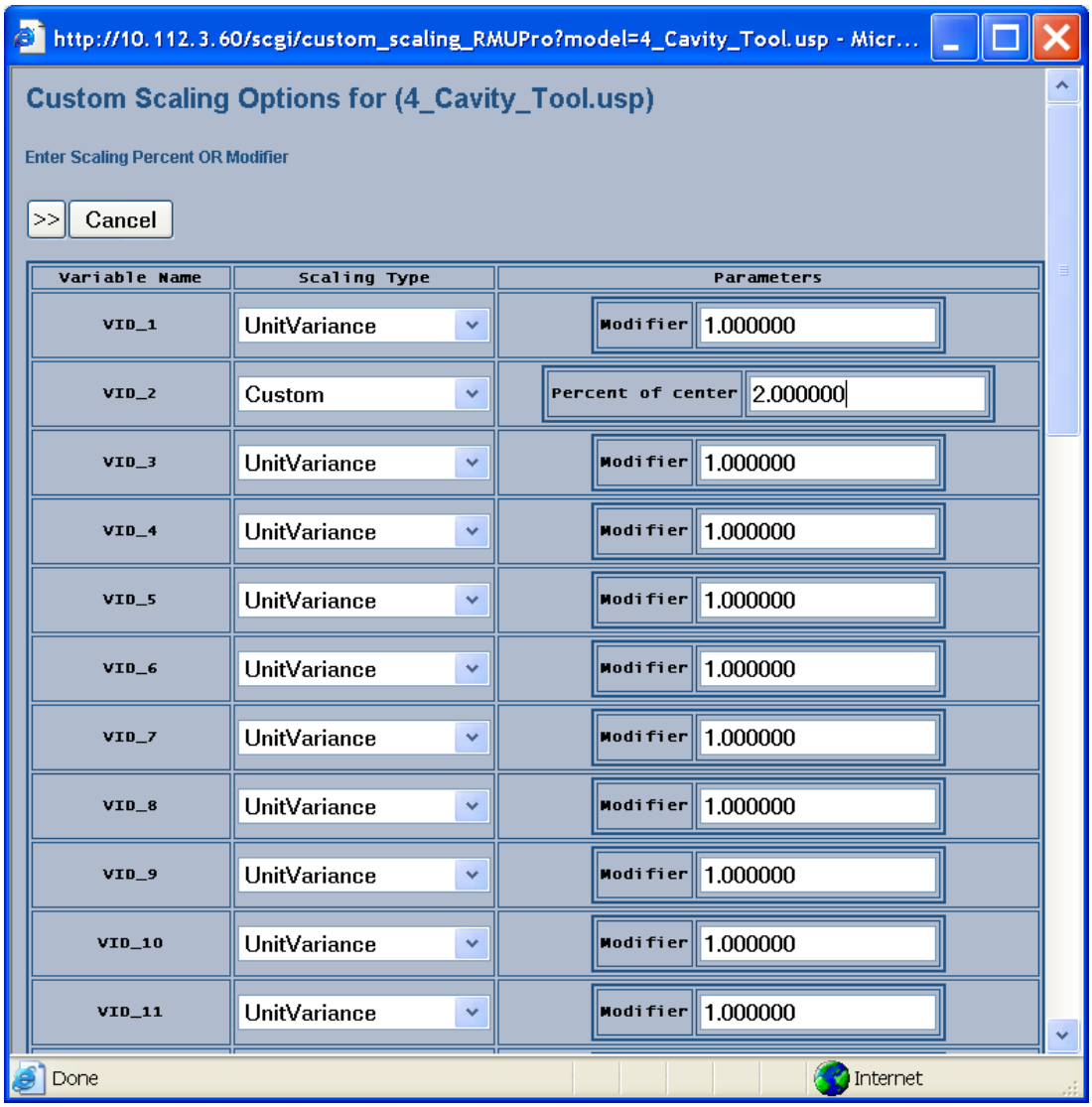


Figure 40 - Custom Scaling

4.12 Running Models

Setting up the model to run can be done by selecting the vertical tab ***Control*** and then the tab ***MVA Config***. From here select the drop down arrow under Models and select the appropriate model.

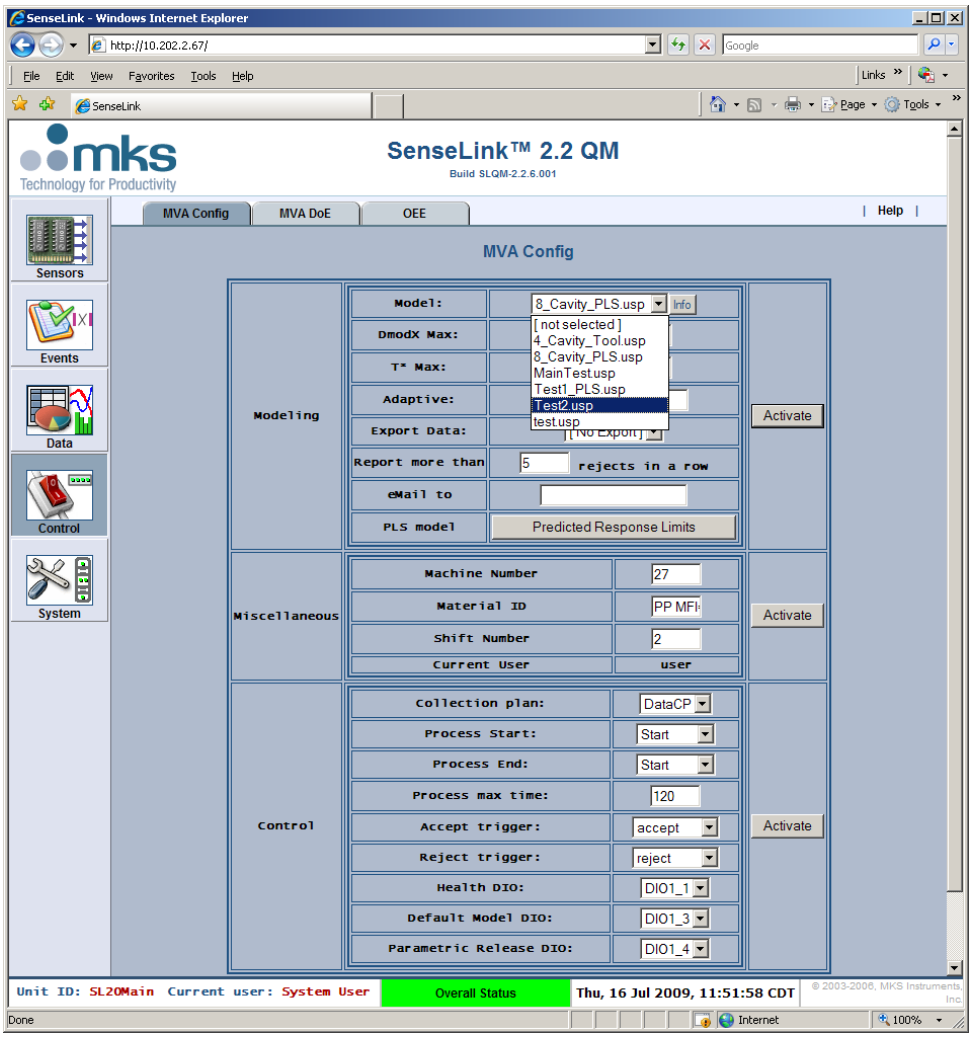


Figure 41 Editing Model Online Through SenseLink

Before selecting Activate, select ***Copy Limits*** to set the DModX and T^2 limits of the selected model.

Also, Adaptive should not be checked and the system should be setup to not export data.

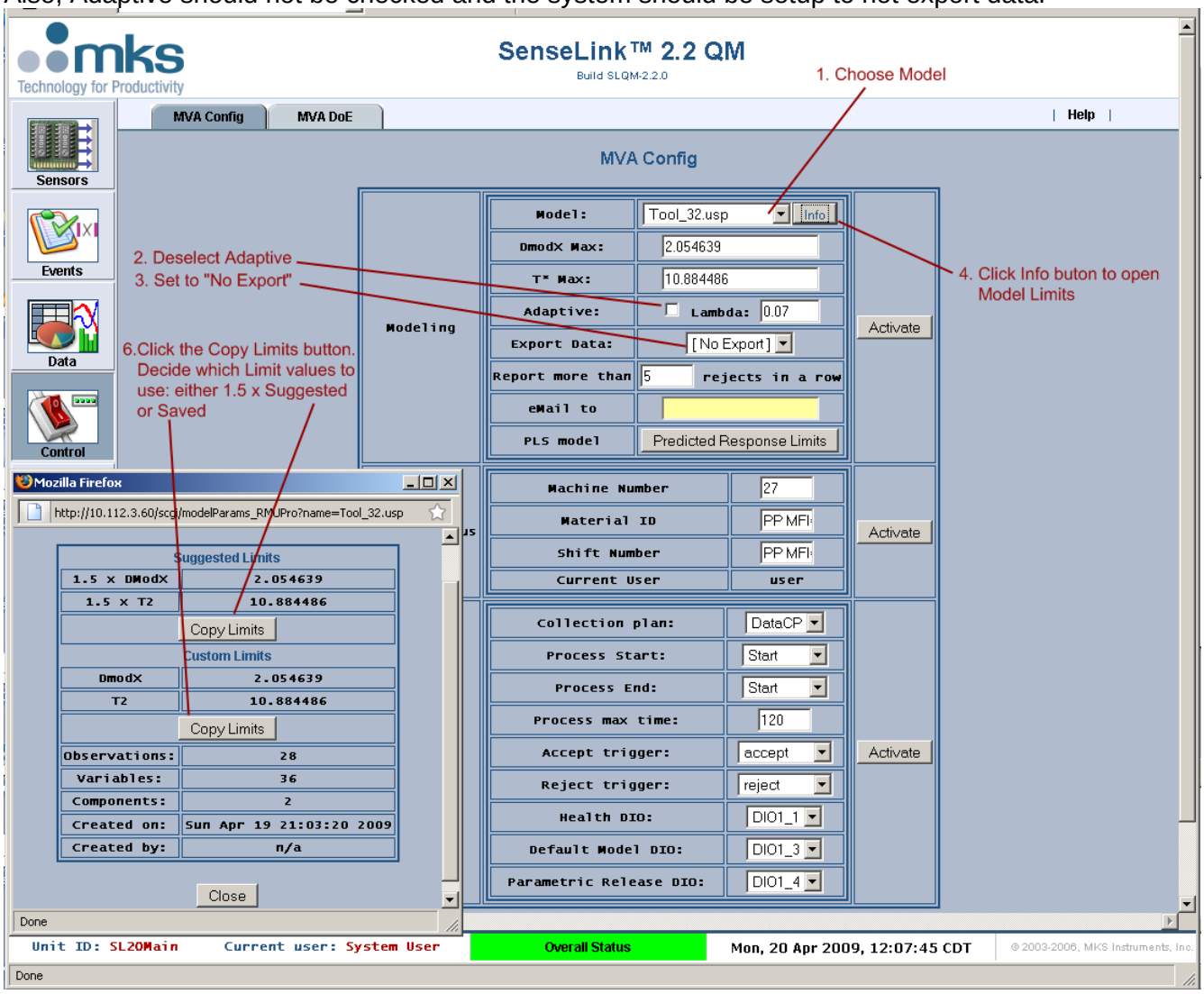


Figure 42 Copying DModX and T^2 Limits

Now select ***Activate*** and the model is now in place.

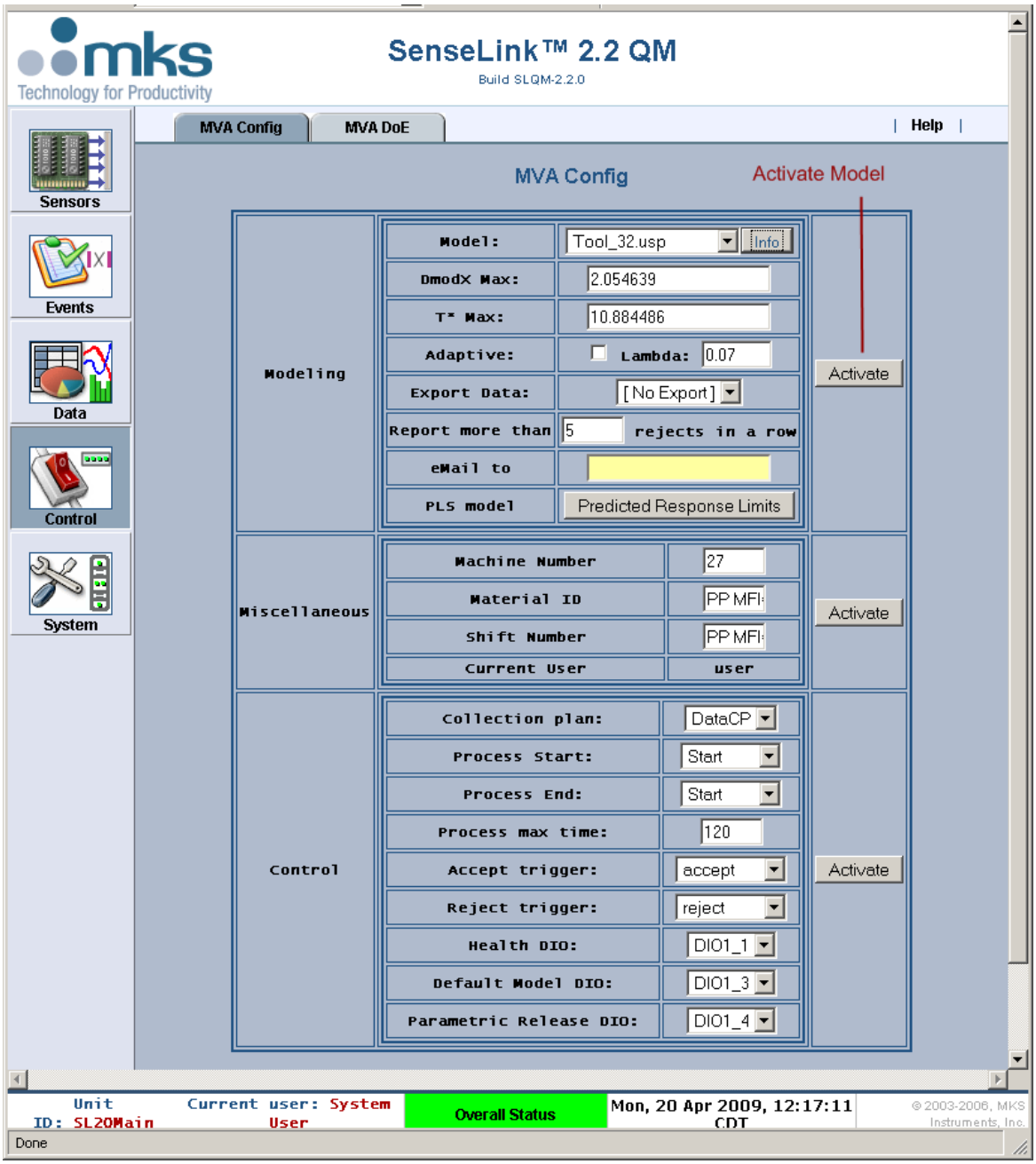


Figure 43 Model Activation

The first two or three shots will be automatically rejected by the system before the new model is fully activated. Any new shots are now being compared to the activated model.

5 SenseLink Hardware

5.1 Hardware Description

The SenseLink is a compact, Linux controller with integrated I/O and peripherals. The CPU will have Linux kernel 2.4.x. All required kernel drivers are preloaded to support current hardware requirements.

There are 5 hardware packages, each to accommodate the number of I/O slots (0-4) Each I/O card has a D-sub 37 connector on both top and bottom. Each cards connector is in the same location, so enclosure cutouts are the same for a DIDO or AIAO card.

The front of the SenseLink provides an operator interface and status indicators. The figure below describes the features on the front panel. These items include I/O indicators, fuses, IP address switches, and diagnostic ports.

The following mechanical drawing is a typical 2 expansion slot model.

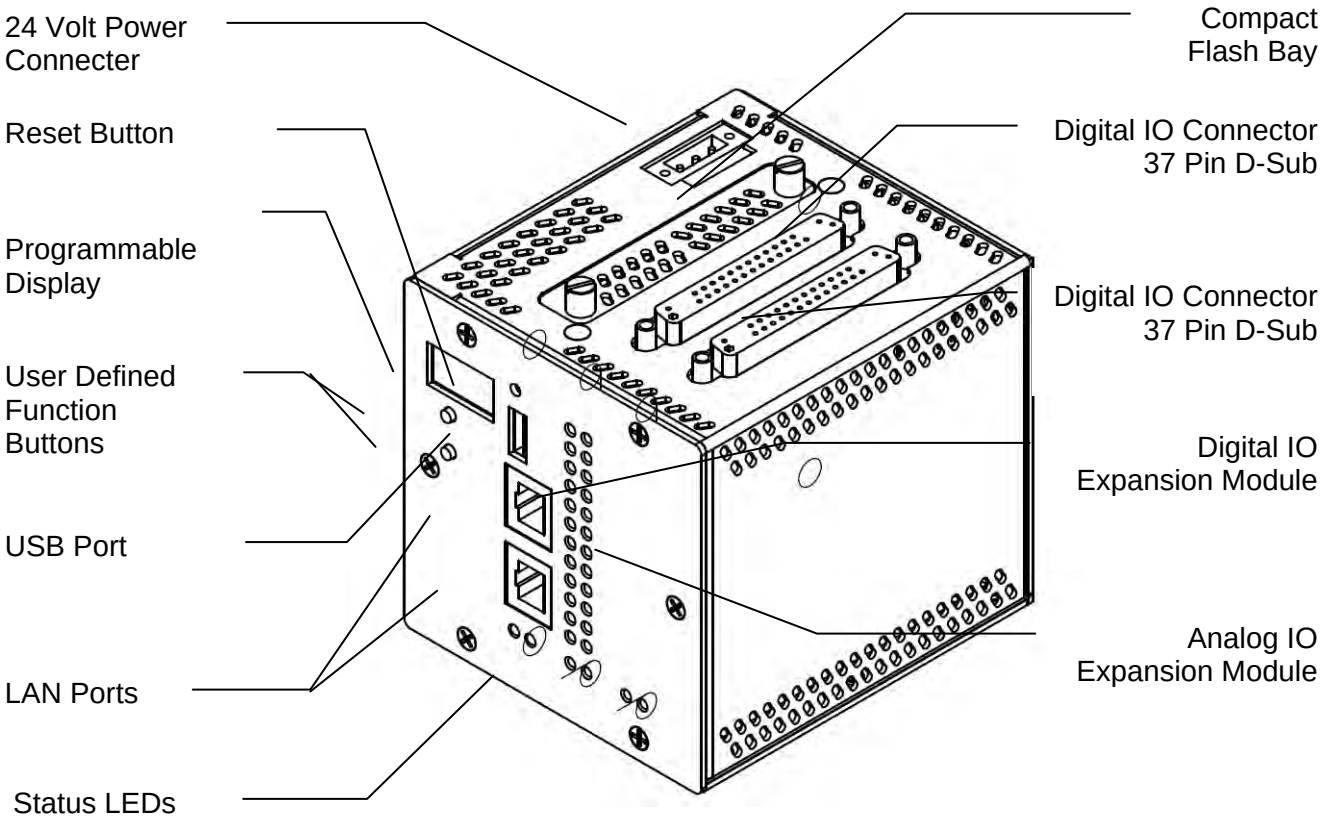


Figure 44 SenseLink Hardware Description

5.2 Mechanical Description

The following mechanical drawing describes a typical 2 slot configuration. Additional slots will cause the unit to be wider but will not change height or depth. Additional mechanical information for other configurations can be obtained through your local MKS representative

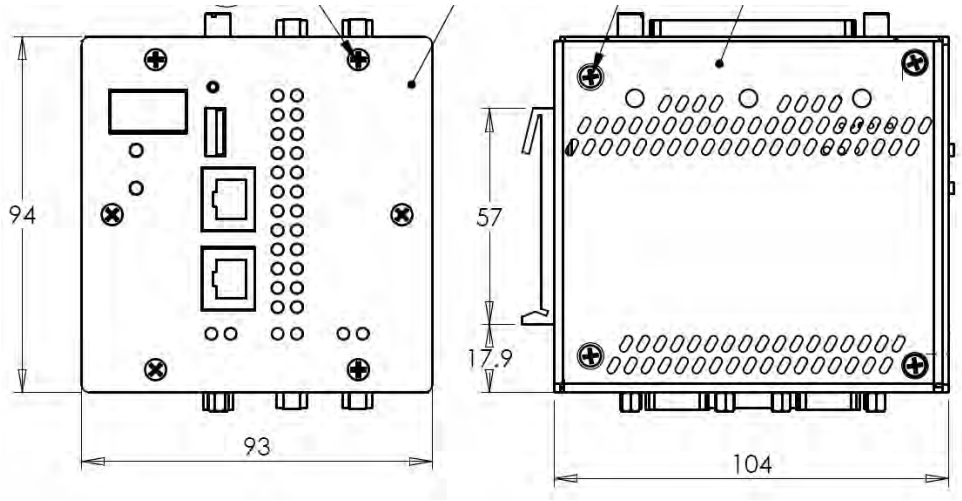


Figure 45 Mechanical Description

Note **ALL DIMENSIONS ARE METRIC**

5.3 Installation

The SenseLink mounts on a standard 35mm DIN rail system. Make sure there is sufficient side clearance for ventilation, to maintain an ambient operating temperature of 0°C to 50°C.

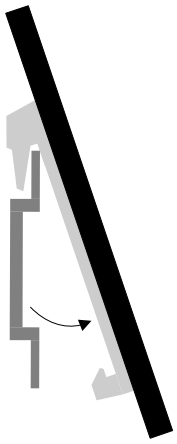


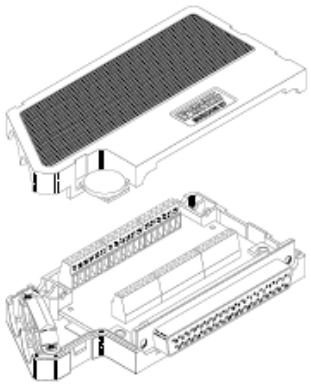
Figure 46 SenseLink DIN Rail Mounting

5.4 Wiring and Hardware Configuration

Ethernet and I/O cables are available from a variety of industrial sources. See table below for orderable I/O mating connectors. Example mating connector for the SenseLink IO is provided in Table 4.

Table 4 Mating IO Connector Information

Description	MFG	Part Number
37-pin D-SUB with Shell (Terminal Block Connections)	Phoenix	2300986



Caution **In order to guarantee proper operation and prevent damage to the product insure that the chasis ground is properly attached for the application.**

Warning **Follow all applicable electrical codes when mounting and wiring any electrical device.**

5.4.1 Power Supply Wiring

Connect an external 18-30 VDC power supply to the 3-terminal Power Connector. The connector

should be wired according to the labeling on the SenseLink.

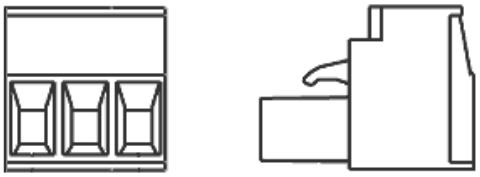


Figure 47 Power Terminal Block Wiring

Table 5 Power Terminal Block Wiring

Pin	Signal
1	18-30 VDC
2	Chassis GND
3	GND

The manufacturer and ordering part number for the SenseLink power terminal block connector is described in Table 6.

Table 6 Terminal Block Information

Description	MFG	Part Number
3-pin Terminal Block	Weidmuller	1625620000

5.4.2 Analog I/O Wiring

The SenseLink QM analog expansion board has two D-Sub 37 connectors used to access the I/O points. Each I/O card type has unique pin assignments; the assignments for the analog card are shown in the following figures.

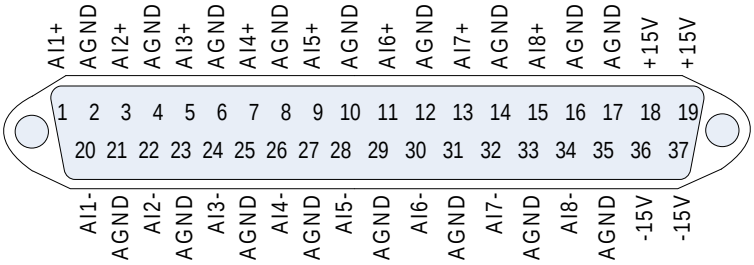


Figure 48 Analog Inputs - Differential Mode

Top Side Connector

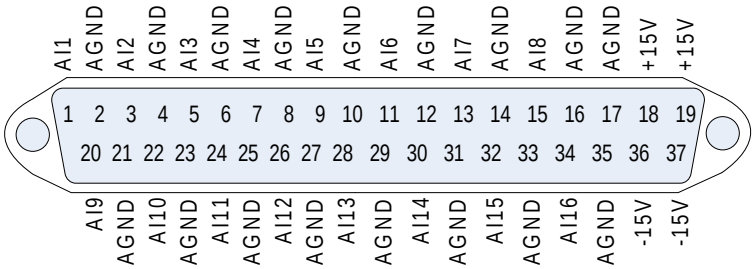


Figure 49 Analog Inputs - Single Ended Mode

Top Side Connector

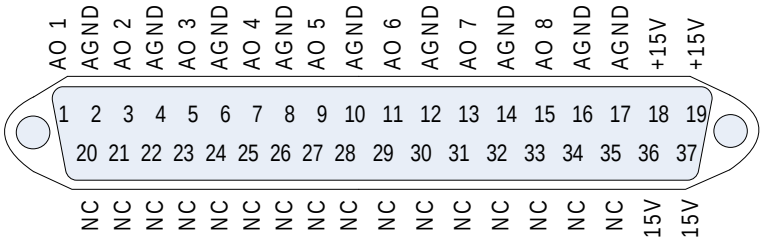


Figure 50 Analog Outputs

Bottom Side Connector

Note **ALL ANALOG POWER COMES FROM AN INTERNAL POWER CONVERTER. EXTERNAL PINS FOR +/- 15 VOLTS SHOULD BE USED AS REFERENCE ONLY. SUPPLIES HAVE LIMITED POWER AND SHOULD NOT BE USED TO DRIVE EXTERNAL LOADS.**

5.4.3 Digital I/O Wiring

The SenseLink digital expansion board has two D-Sub 37 connectors used to access the I/O points. The +24V power must be supplied by an external source via these connectors. Each I/O card type has unique pin assignments; the assignments for the digital card are shown in the following figures. All the 24 GNDs are one net. The configuration of the SenseLink QM software is by default set for sourcing, so it is recommended to wire the digital board as Source per Table 7.

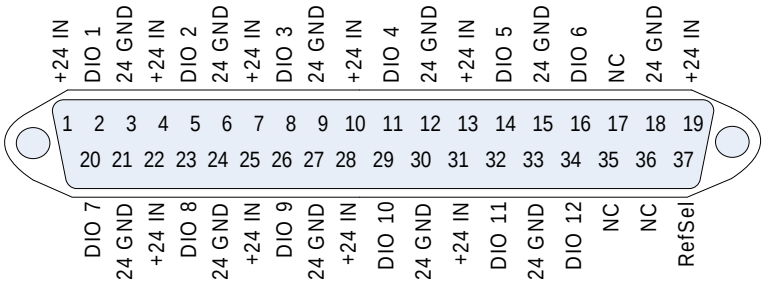


Figure 51 Digital Top Side Connector

Table 7 Source/Sink Select for Digital Top Connector

Sink/Source Select	
Source	**Short Pin 18 to 37**
Sink	**Short Pin 19 to 37**

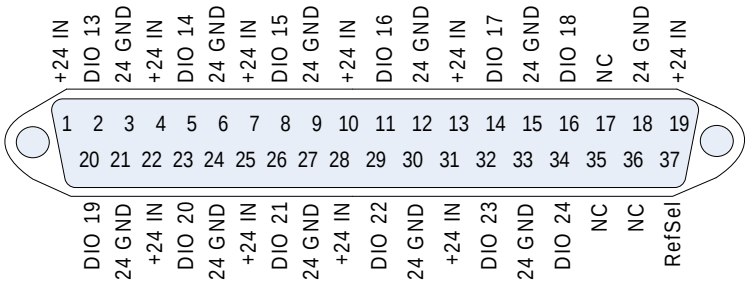


Figure 52 Digital Bottom Side Connector

Table 8 Source/Sink Select for Digital Bottom Connector

Sink/Source Select	
Source	**Short Pin 18 to 37**
Sink	**Short Pin 19 to 37**

5.4.4 Combo I/O Wiring

The Combo I/O Expansion Card has two 37-pin D-Sub connectors used to access the I/O points. The +24V power must be supplied by an external source via these connectors. The +/- 15V power is supplied by an internal converter. The pin assignments are shown in the following tables. All the 24 GNDs are one net.

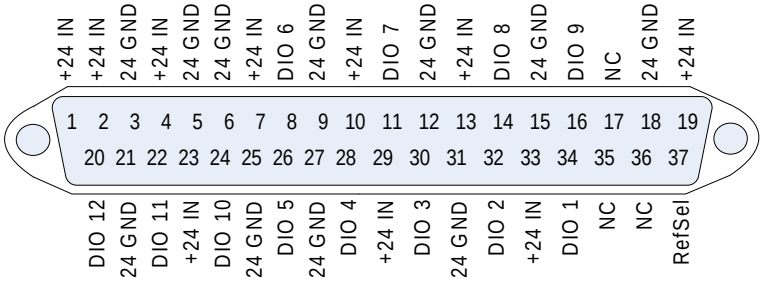


Figure 53 Combo Top Side Connector

Table 9 Source/Sink Select for Combo Top Connector

Sink/Source Select	
Source	**Short Pin 18 to 37**
Sink	**Short Pin 19 to 37**

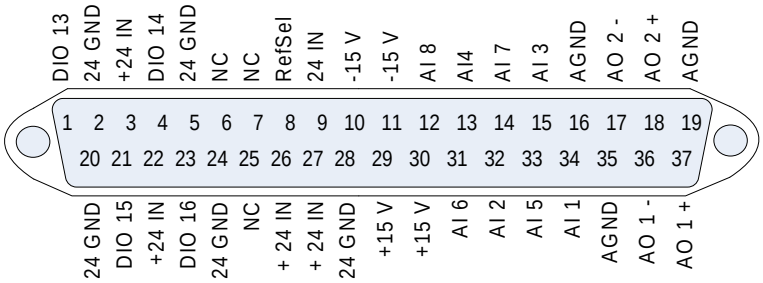


Figure 54 Combo Bottom Side Connector

Table 10 Source/Sink Select for Combo Bottom Connector

Sink/Source Select	
Source	**Short Pin 28 to 8**
Sink	**Short Pin 27 to 8**

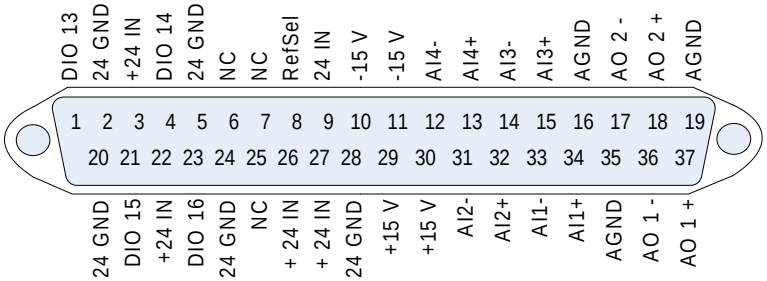


Figure 55 Combo Bottom Side Connector (Differential)

Table 11 Source/Sink Select for Combo Bottom Connector

Sink/Source Select	
Source	**Short Pin 28 to 8**
Sink	**Short Pin 27 to 8**

Note

ALL ANALOG POWER COMES FROM AN INTERNAL POWER CONVERTER. EXTERNAL PINS FOR +/- 15 VOLTS SHOULD BE USED AS REFERENCE ONLY. SUPPLIES HAVE LIMITED POWER AND SHOULD NOT BE USED TO DRIVE EXTERNAL LOADS

5.5 Digital Inputs

Digital I/O can be ordered as either sinking (active low) or sourcing (active high) I/O. Each input circuit includes an indicator LED in series with the detection opto-coupler. The opto-coupler isolates the processor from the inputs. The inputs require 1.5mA in order to turn on.

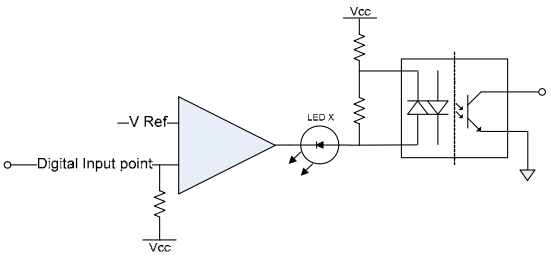


Figure 56 Sinking Input

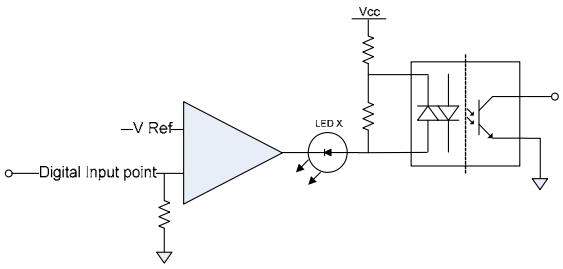


Figure 57 Sourcing Input

5.6 Digital Input Interface Example

Below is an example of how to use the digital input interface for both the sinking and sourcing hardware configurations. The digital I/O circuitry is powered from an external +24-volt power source via the I/O connector.

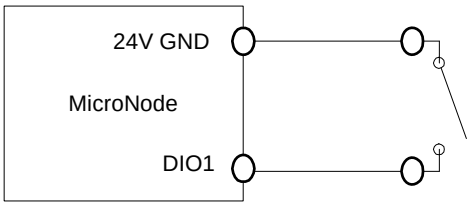


Figure 58 Sinking Input

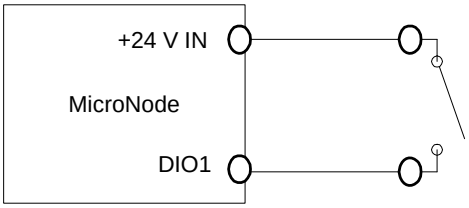


Figure 59 Sourcing Input

5.7 Digital Outputs

The individual outputs will support up to a 200 mA load per channel. Each output is thermally protected against short-circuiting (500 mA typically) and includes under voltage protection. The output Fault State is accessible through software. External Schottky diodes are provided for output transient protection and each I/O point is protected with a self-resetting poly fuse rated for 500 mA. Outputs default to the OFF condition during power up and processor reset conditions. The figure below shows the output circuitry.

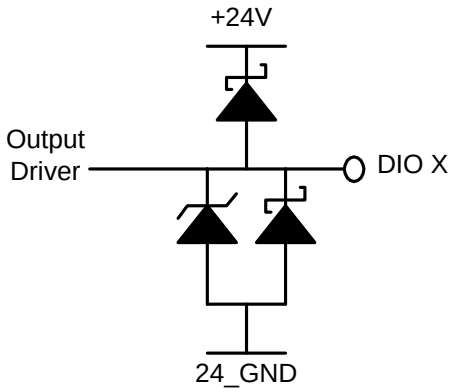


Figure 60 Digital Output

5.8 Digital Output Interface Example

Below is an example of how to interface with the digital outputs for both the sinking and sourcing hardware configurations. The digital I/O circuitry is again powered from an external +24-volt power source via the I/O connector.

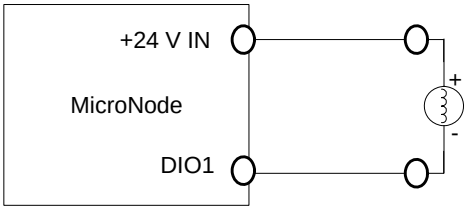


Figure 61 Sinking Output

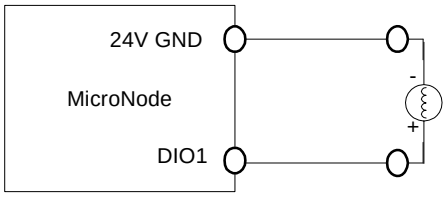


Figure 62 Sourcing Output

5.9 Analog Inputs

The analog inputs are coupled directly to the processor and are implemented using 12 bit A/D converters. The analog input range is –10V to +10V.

All analog circuitry is powered from an internal ±15 Vdc power source. The +15 V and -15 V power is protected with a self-resetting poly fuse rated at 100 mA.

Table 12 Analog Voltage Conversion

Conversion Table	
10 V	0x1FFF
5 V	0x0FFF
0.0012 V	0x0001
0 V	0x0000
-0.0012 V	0xFFFF
-5 V	0x2FFF
-10 V	0x2000

Table 13 Analog Description

Card Type	Number of Inputs	Type
Analog Expansion Card	16	Single ended inputs
Combo Expansion Card	8	Single ended inputs that can also be connected in pairs to create differential inputs. Particular pairs must be used (input 1-5, 2-6, 3-7, 4-8) if a differential input is required.

5.10 Analog Outputs

The analog outputs are implemented using 12 bit D/A's with a –10V to +10V output range. The output drivers are capable of driving 2 Kohm (5 mA) output loads. Analog outputs default to 0 volts during power up and processor reset conditions.

Table 14 Analog Voltage Conversion

Conversion Table	
10 V	0x0FFF
5 V	0x0BFF
0 V	0x07FF
-5 V	0x03FF
-10 V	0x0000

Table 15 Analog Description

Card Type	Number of Outputs	Type
Analog Expansion Card	8	Single ended outputs
Combo Expansion Card	2	Differential outputs

5.11 Serial Port Connections

The SenseLink contains four total serial communication ports. Connector is standard D-Sub 9 pin male. COM1 and COM2 are RS232 only. COM3 and COM4 are RS232/RS485 Software selectable.

Table 16 Serial Port Connections

Pin	Signal – RS232
1	
2	Rx
3	Tx
4	jmp
5	GND
6	jmp
7	
8	
9	

Pin	Signal – RS485HD
1	
2	Tx
3	Tx
4	*jmp*
5	GND
6	*jmp*
7	Rx
8	Rx
9	

Pin	Signal – RS485FD
1	
2	Rx-
3	Tx-
4	*jmp*
5	GND
6	*jmp*
7	Tx+
8	Rx+
9	

For RS485 half-duplex mode, pin2, pin3 (Tx) need to be tied together. Pin7, pin8 (Rx) also need to be tied together.

5.12 Network Configuration

The SenseLink has 2 LAN 100/10 BaseT Ethernet ports. The following are factory-default ethernet settings.

Table 17 LAN 1 Configuration

Parameter	SenseLink Setting
IP-Address of eth0	DHCP
Subnet Mask	None
Default Gateway	None

Table 18 LAN 2 Configuration

Parameter	SenseLink Setting
IP-Address of eth1	192.168.1.2
Subnet Mask	255.255.255.0
Default Gateway	None

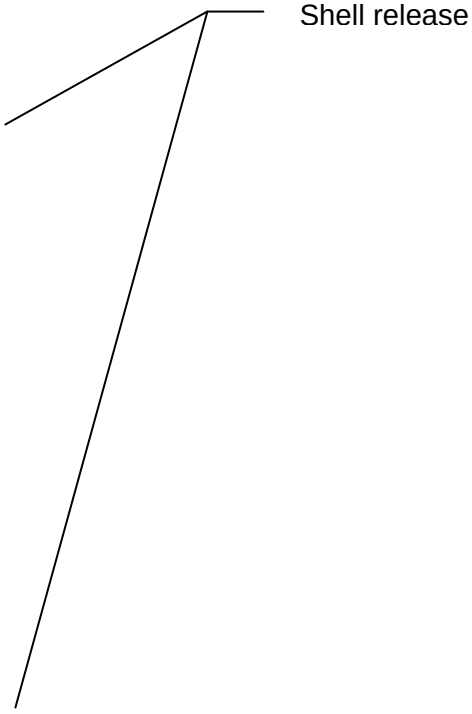
Reading or changing the network settings of an unknown unit is achieved by connecting via a serial terminal session.

5.13 Weidmuller Thermocouple Module

This section provides the basic configuration and setup for the Weidmuller Thermocouple Module used with the SenseLink hardware. This document outlines the configuration of the thermocouple, wiring and installation, and configuring the analog input channel formula.

5.13.1 Configuring the Weidmuller Thermocouple

The Weidmuller Thermocouple Module is configured via two, eight position dip switches. The dip switches are accessed by removing the shell of the Thermo Select Module



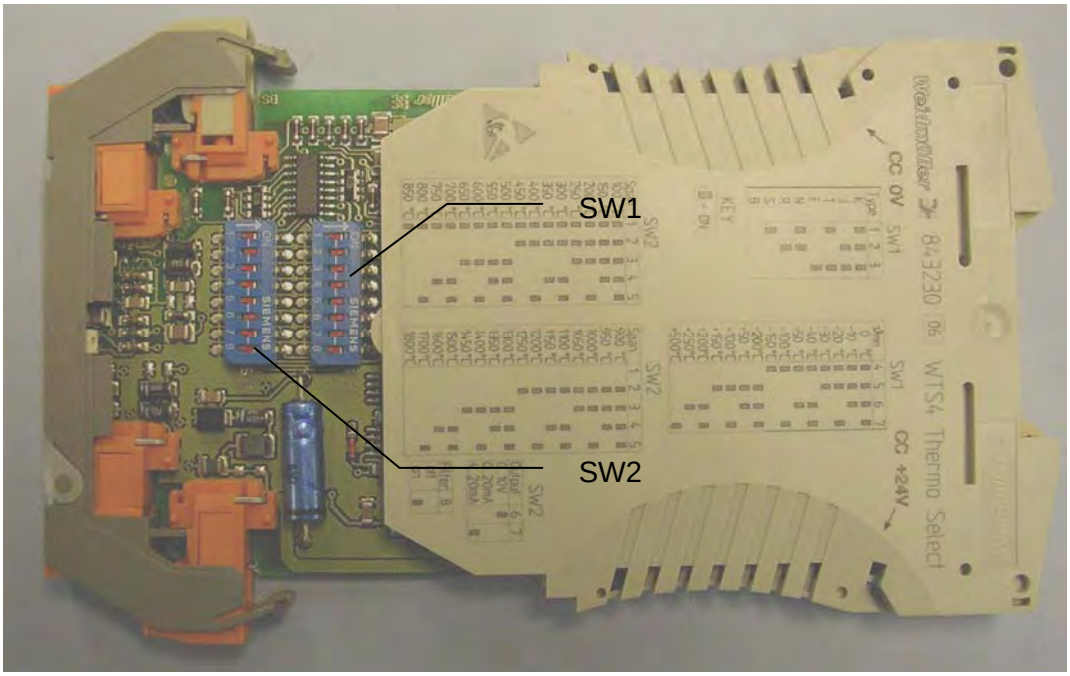


Figure 63 Weidmuller Thermocouple Module

The following describes the configuration for use with the SenseLink:

Table 19 Switch 1

Pin	Switch Position	SW1 Description
1	OFF	Switches 1,2,3 are used to describe the type of thermocouple being used, This application is for a Type J.
2	ON	
3	ON	
4	ON	Switches 4,5,6,7 are used to set the minimum temperature. This application used 0 degrees.
5	ON	
6	ON	
7	ON	
8	ON	Has no function

Table 20 Switch 2

Pin	Switch Position	SW2 Description
1	OFF	Switches 1-5 are used to set the temperature span. This application will use 1250 degrees.
2	ON	
3	OFF	
4	OFF	
5	OFF	
6	ON	Switched 6 and 7 are used to set the output mode. This application used 0-10 volts
7	OFF	
8	OFF	Switch 8 is to enable the filter. The filter will be disabled for this application as it would have a 6

		second delay if enabled.

5.13.2 Wiring and installation

Wiring the thermocouple into the thermocouple module is done by connecting the positive lead to pin 1 and the negative lead to pin 3.

Connecting the supply to the thermocouple module is done by connecting 24 volts to pin 7 and connecting the common to pin 8.

Connecting the thermocouple to the SenseLink is done by connecting pin 6 of the thermocouple module to the AIN+ channel of the SenseLink. The AIN- of the SenseLink should connect to the 24 volt common used to power the thermocouple module.

Table 21 Weidmuller Thermocouple Pinout

Pin	Description
1	Thermocouple Positive Input
3	Thermocouple Negative Input
8	Temperature Output 0-10 Volts
9	Analog Common
10	24 Volt Supply
11	24 Volt Common

5.13.3 Calibrating Thermocouples

Setting up the analog inputs for the temperatures requires scaling the inputs so that they represent actual data values from the molding machine. First, name the signal. Adding the scale is accomplished by clicking on the corresponding scale for the channel indicated after you select ***Edit Inputs***.

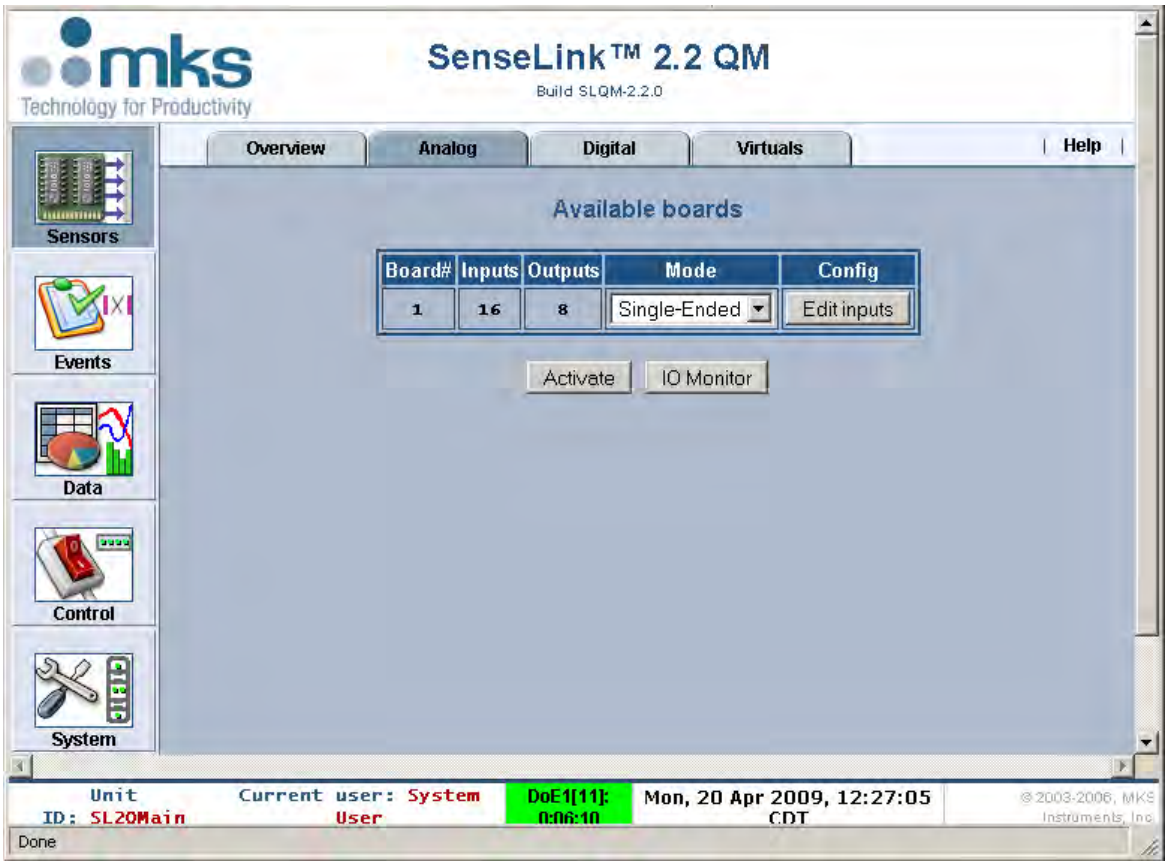


Figure 64 Analog Tab

Select ***n/a*** under Scaling will open the Channel Configuration Wizard window. Select formula and click next.

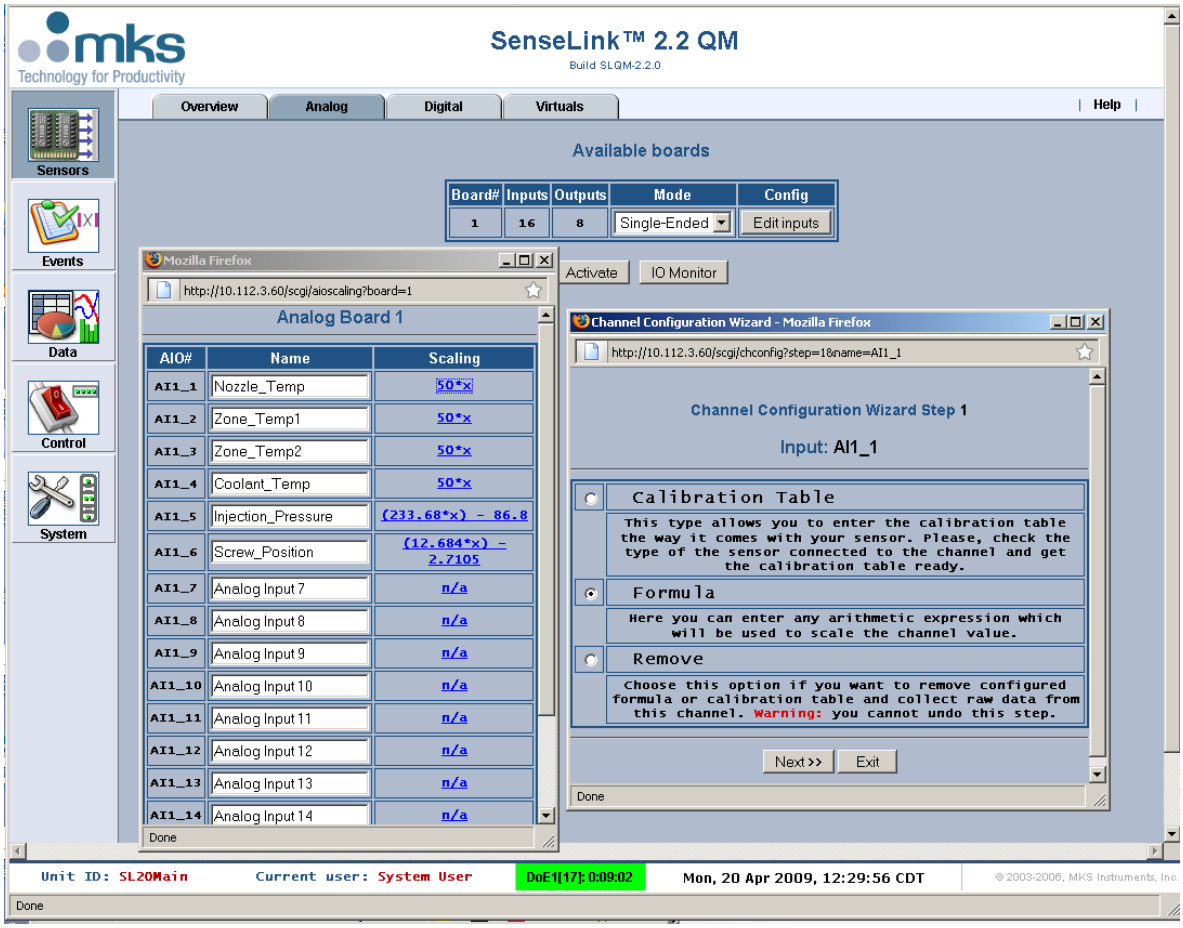


Figure 65 Scaling window

Calibrating the temperature inputs are dependent on the range the thermocouple module was set to. Various examples of temperature ranges along with the corresponding equations are shown in the table below. Converting from °C to °F is done by multiplying by 1.8 and adding 32.
Example equation: ((50*x)*1.8)+32

Table 22 Calibration Equations for Various Temperature Ranges

Temperature Range (°C)	Corresponding Equation (°C)
0 – 500	50*x
0 – 300	30*x
100 – 300	(20*x)+100
100 - 500	(40*x) + 100
150 - 300	(15*x) + 150
150 - 350	(20*x) + 150

Once you select ***Formula*** from Figure 65, shown above, the following window is displayed. The equations above can be copied and pasted directly into this window.

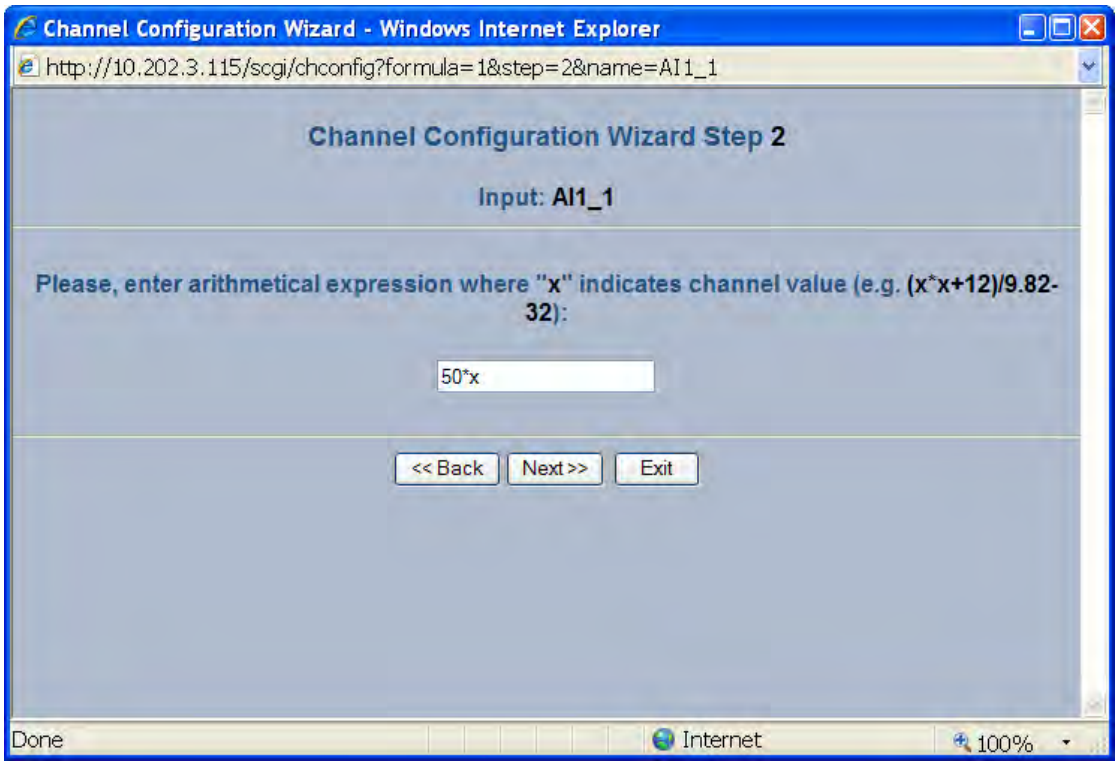


Figure 66 Calibration Formula

6 SenseLink™ QM User Interface

The SenseLink user interface is web based. You can access it by simply browsing to the IP-Address of the SenseLink™.

Note Microsoft Internet Explorer 5.0.1 or higher is required. Microsoft Internet Explorer versions less than 5.5 may not function as expected due to limitations of the browser.

The user interface is divided into five main tabs:

- **Sensors**
  Allows the user to change the settings of the analog, digital, and virtual inputs
- **Events**
  Allows the user to create any events or triggers
- **Data**
  Allows the user to observe, download, and export process data
- **Control**
  Allows the user to create collection plans, run DOE's, and create and modify the model
- **System**
  Allows the user to change the basic time and network settings, modify users rights, and to upload software updates

Additional tabs may be implemented for application specific requirements. If additional functionality is required, work with MKS to determine feasibility. Application specific functionality will be provided in an addendum to this manual.

6.1 Sensors Overview

The sensors overview tab displays each of the analog and digital cards that are configured with the SenseLink QM.

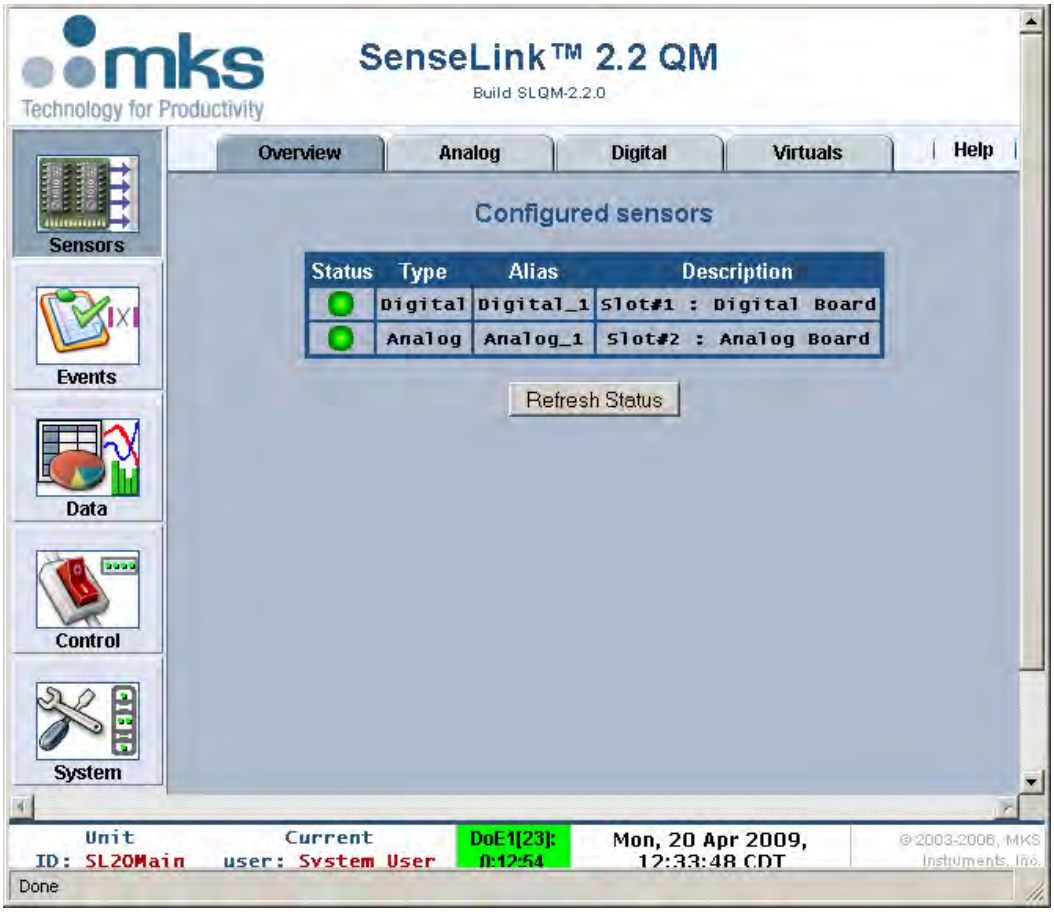


Figure 67 Sensors Overview

6.1.1 Analog Channels

Select the ***Analog*** tab to create and edit the analog signals.

6.1.1.1 Changing the Card Type

To change the analog board to Single-Ended or Differential mode click on the drop down arrow and select the mode to match the card type and select ***Activate***.

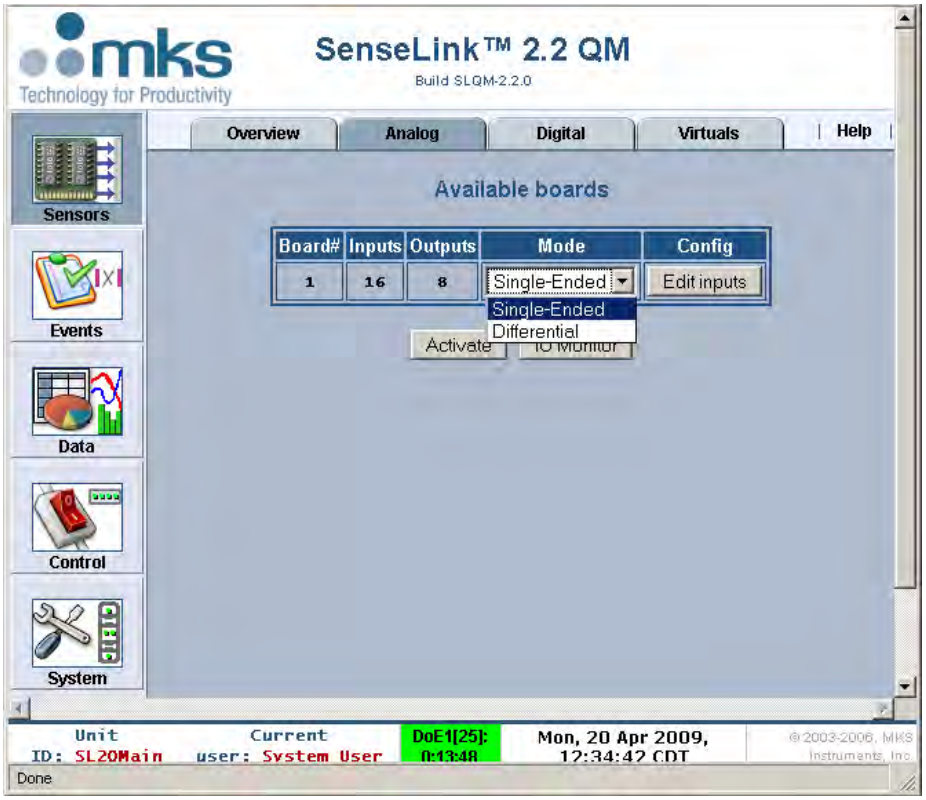


Figure 68 Selecting Analog Boards

6.1.1.2 Changing the Name of a Channel

To change the name of a channel, simply edit the appropriate field. The changes will become active after pressing the ***Save*** button. The ***Activate*** button must then be selected to submit the change.

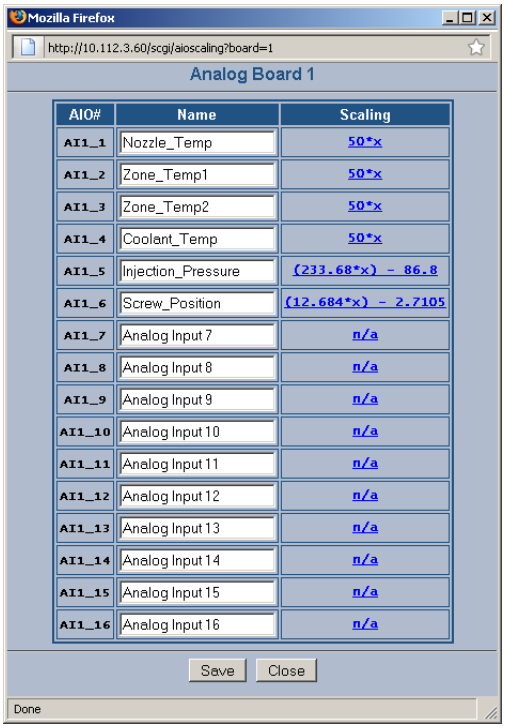


Figure 69 Configuring Analog Signals

6.1.1.3 Changing the Scaling of a Channel

To change the scaling of a channel, click on the link in the column: ***Scale***. A new window displays:

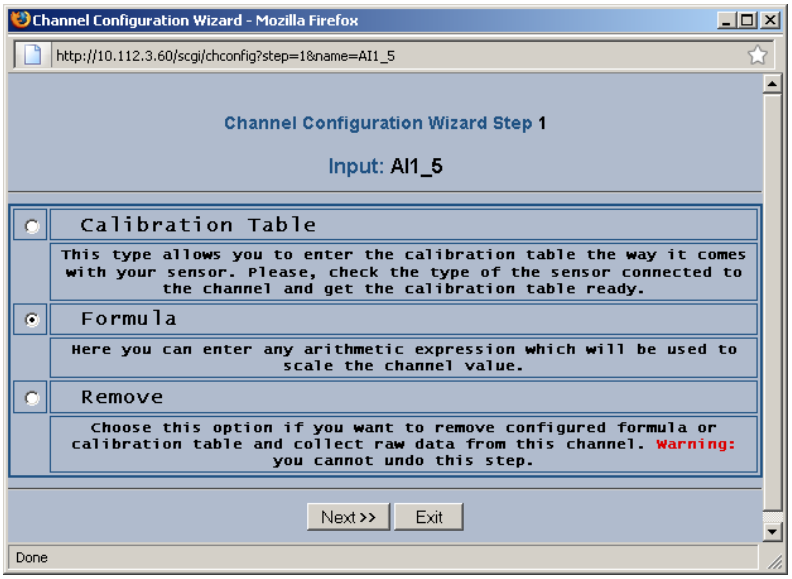


Figure 70 Scaling Analog Signals

You can select to:

- Enter a calibration table manually
- Enter the calibration via a formula
- Remove a calibration from a channel

6.1.1.4 Enter Calibration via Table

This option allows you to enter the calibration table and test it.
The format of the calibration table is: Input Value=Output Value, where the input value is the raw voltage data and the output value is the calibrated value. It is important that a maximum and minimum value for the signal is used when using the calibration table.

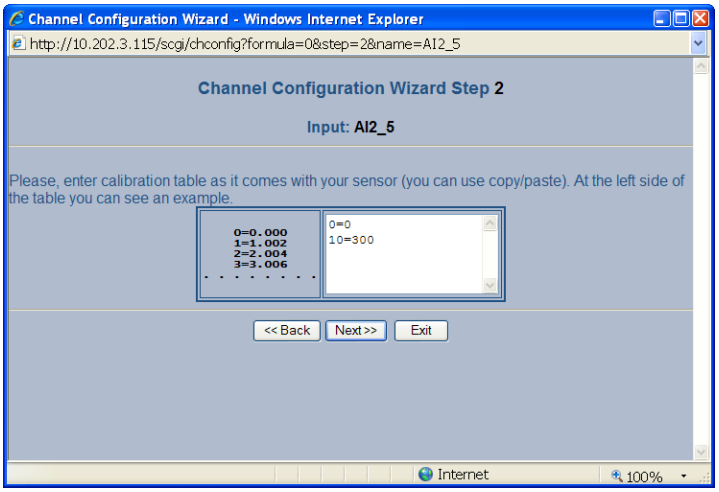


Figure 71 Creating Analog Calibration Tables

In the next step of the channel configuration, you can test the calibration by downloading the chart of a given input range or you can save the calibration table.

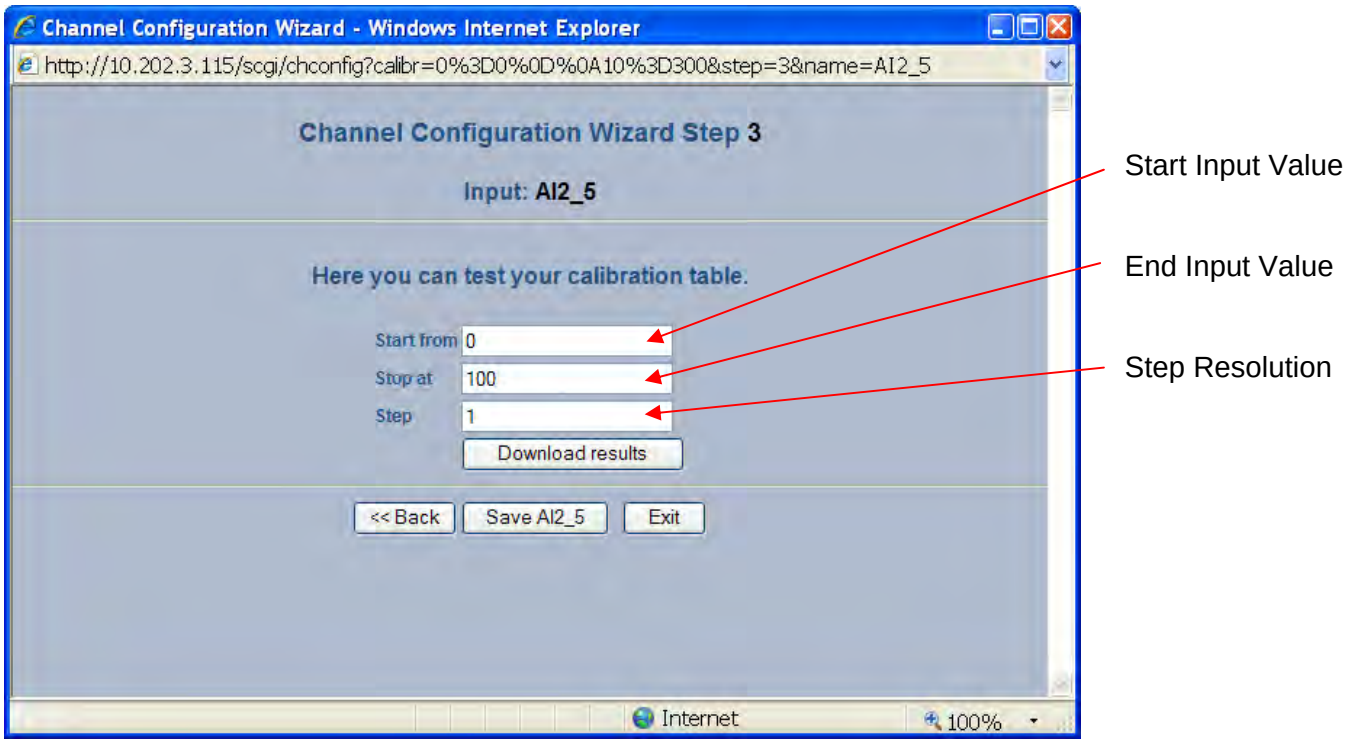


Figure 72 Validating the Calibration Table

Clicking ***Download results*** will export the calculated calibration chart as a .csv type document. After checking the results, select the ***Save*** button to keep the entered calibration table.

6.1.1.5 Enter Calibration via Formula

Setting up a Formula can be done using the expressions described in the table below. When generating formulas spacing does not matter. Negative numbers are handled as 0-x. The order of operations for the expressions follow standard precedence such as in C Coding.

After entering the formula, select ***Next***, you then have the option of downloading the results and saving the formula.

Figure 73 Editing Signal Calibration Formulas

6.1.1.6 Removing the Formula

Removing a formula or calibration table can be done simply by selecting the formula or table under the scaling column, selecting ***Remove***, and clicking ***Next***.

Figure 74 Removing Calibration Formulas/Tables

6.1.1.7 Validating the Signals

Once the signals are named and scaled, select the ***IO Monitor.***

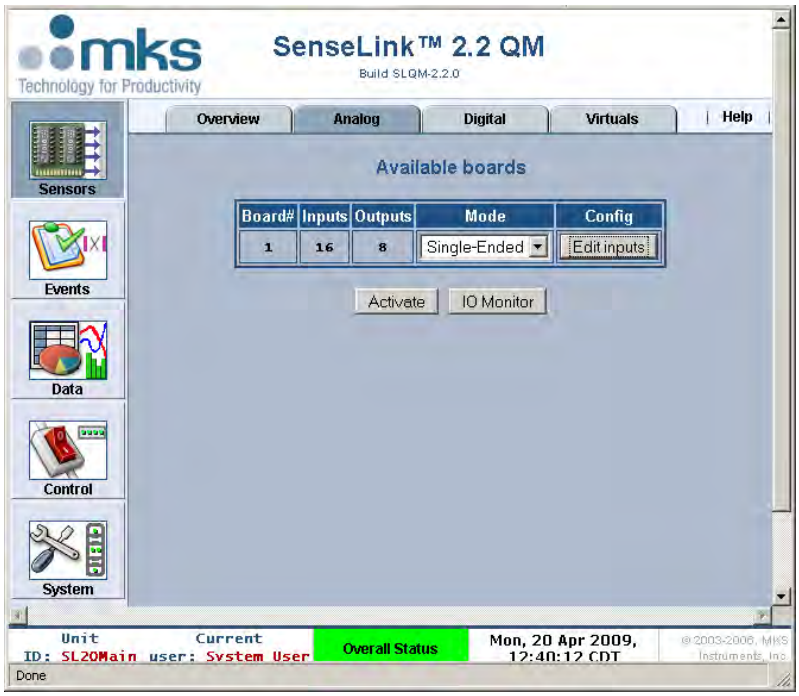


Figure 75 IO Monitor to view signal values

This monitoring window can be used to ensure that all of the signals are changing and functioning properly. This window displays the signals with their raw voltage values.

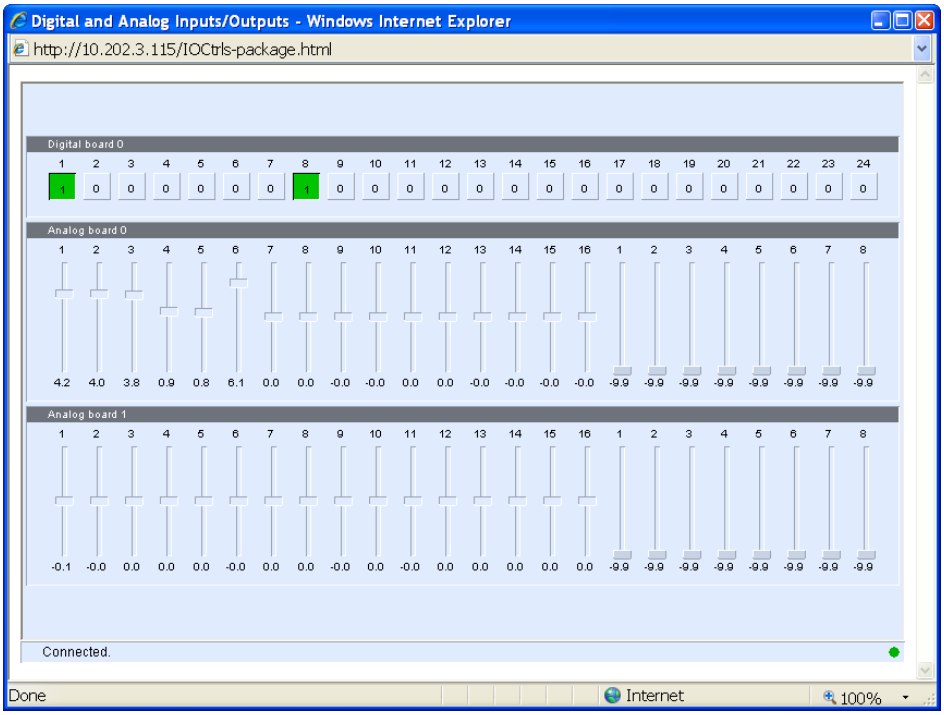


Figure 76 Signals IO Monitor

6.1.2 Digital Channels

Select the ***Digital*** tab to create or edit digital inputs and label them as outputs or inputs. Select the ***Save*** button when all of the digital signals are entered. Again, the ***IO Monitor*** page can be used to validate the signals.

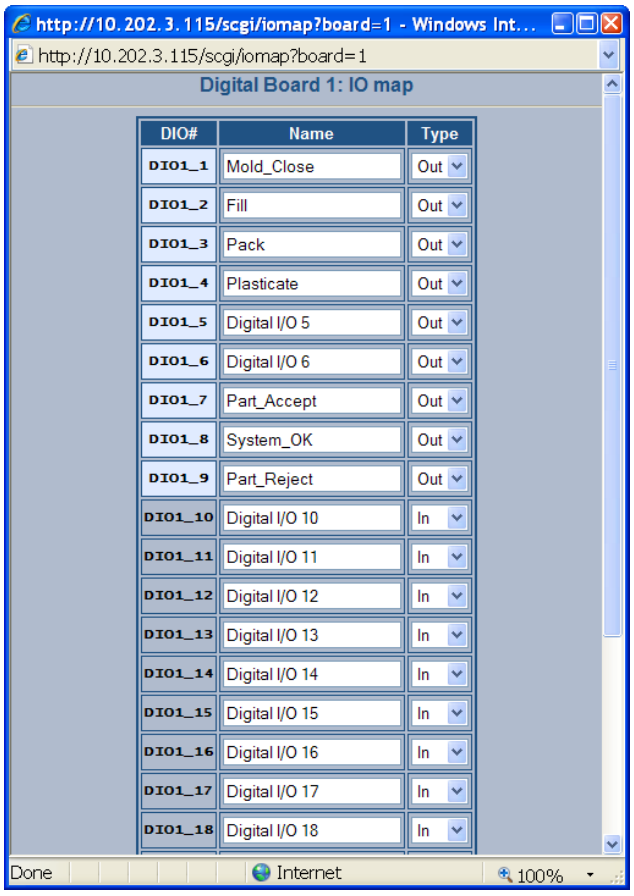


Figure 77 Editing Digital Signals

6.1.3 Virtual Channels

The Virtuals tab is used to create process data features. A virtual input is used when performing logic and mathematical functions to analog and digital inputs and also events. This allows for complex input functions to be handled in real time by the SenseLink. Each virtual input has a definable description and formula inputs. The ***Edit*** button can be used to modify or delete features.

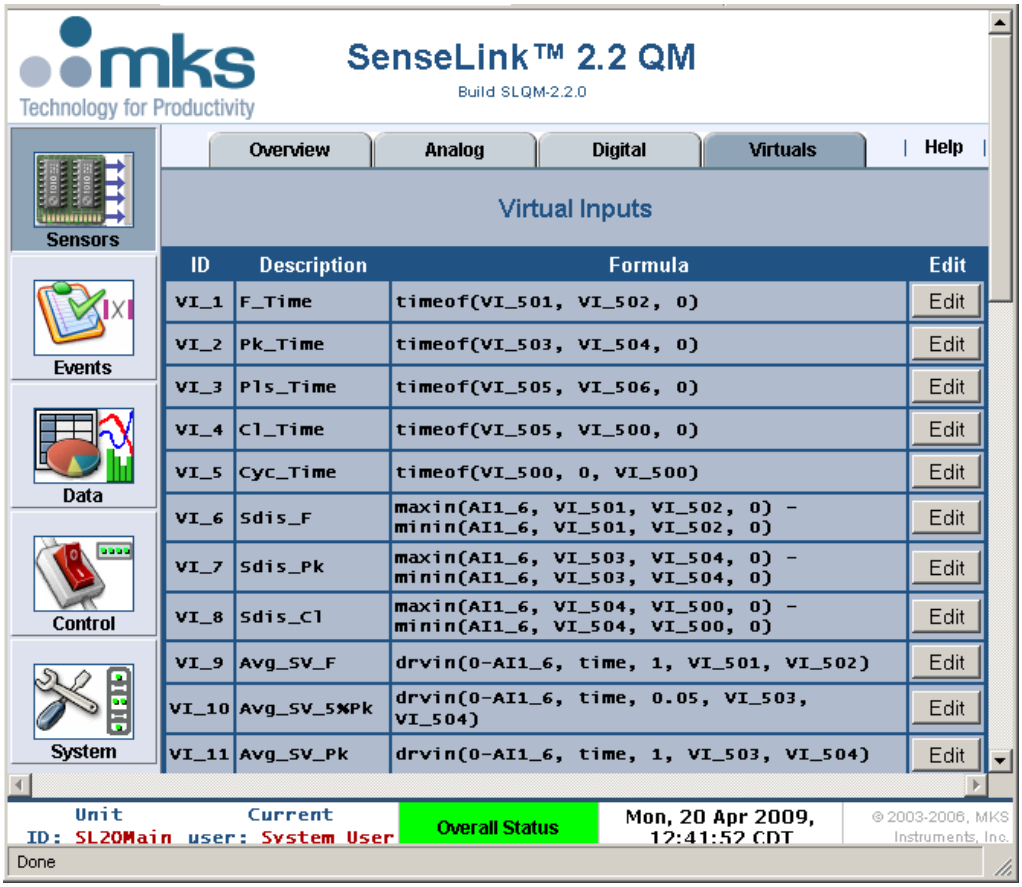


Figure 78 Creating/Editing Virtuals

6.2 Events Overview

Selecting the main tab ***Events*** will bring up the following window. On this page, the events, triggers, and status of the events can be modified.

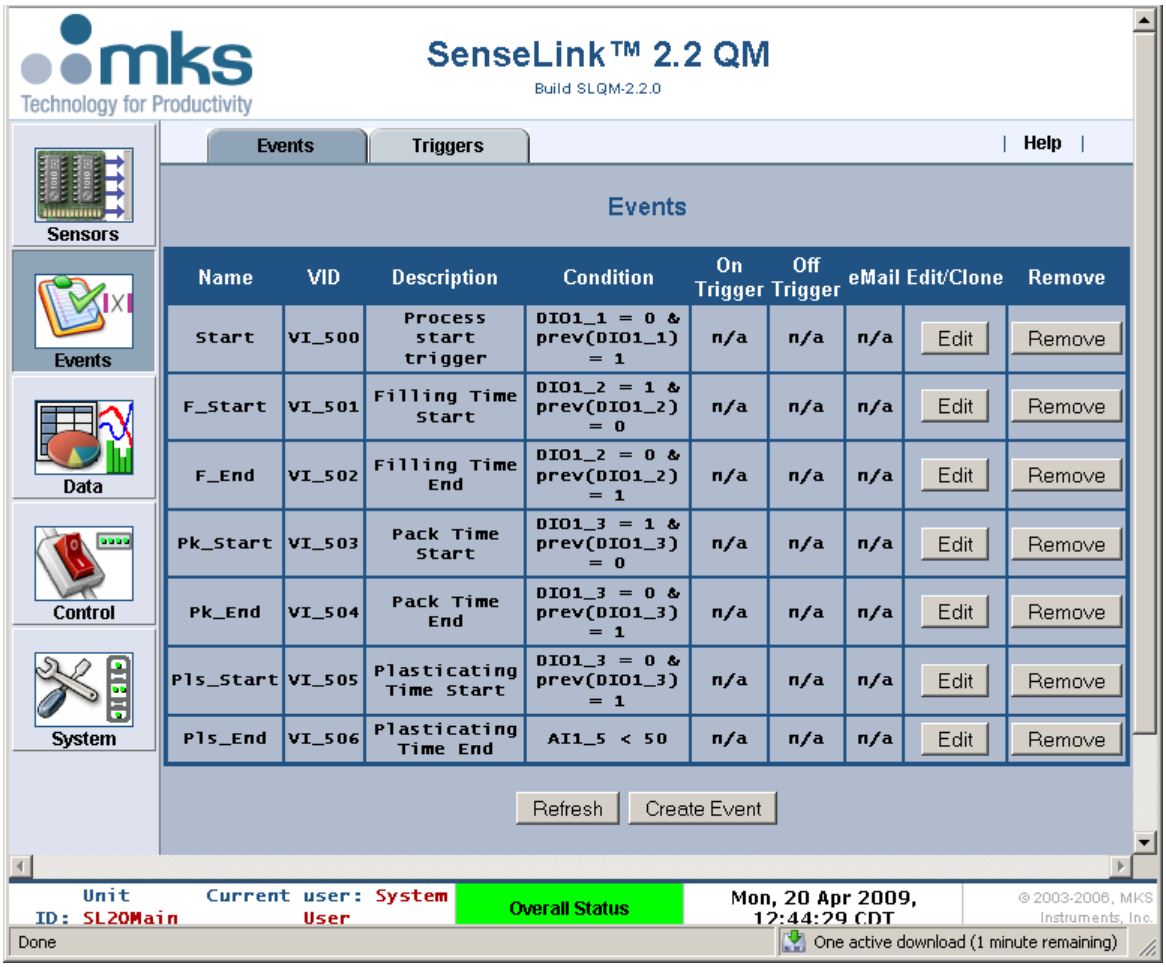


Figure 79 Creating/Editing Process Events

6.2.1 Events

Events are created to separate the different timing stages or events of the injection molding process and simplify the analysis. The typical events that should be created are cycle start and end, filling start and end, packing start and end, and plasticating start and end. These events can then be easily referred to when creating the data features or virtuals. Selecting the ***Create Event*** tab will bring up the following window. Edit the name, description, and condition for the event then select ***Save Event***.

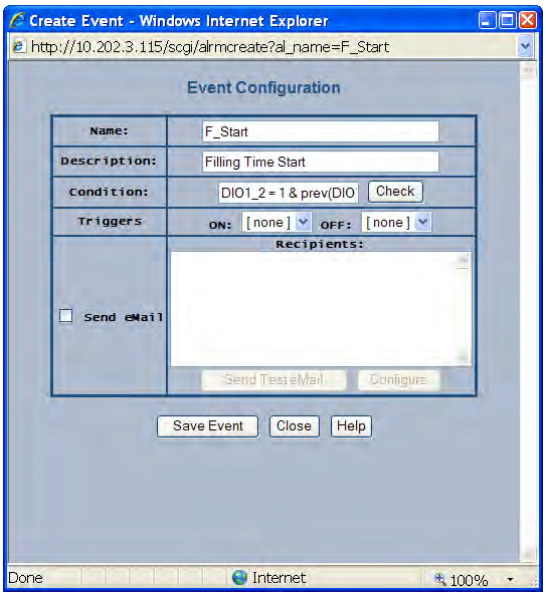


Figure 80 Configuring Events

6.2.2 Triggers

Triggers are used to create some type of action such as a light or conveyer when a part is accepted or rejected. Setting the conditions for the triggers can be done in the same manner as setting the formulas in the Virtual tab. The condition formulas support the same operators as virtual inputs.

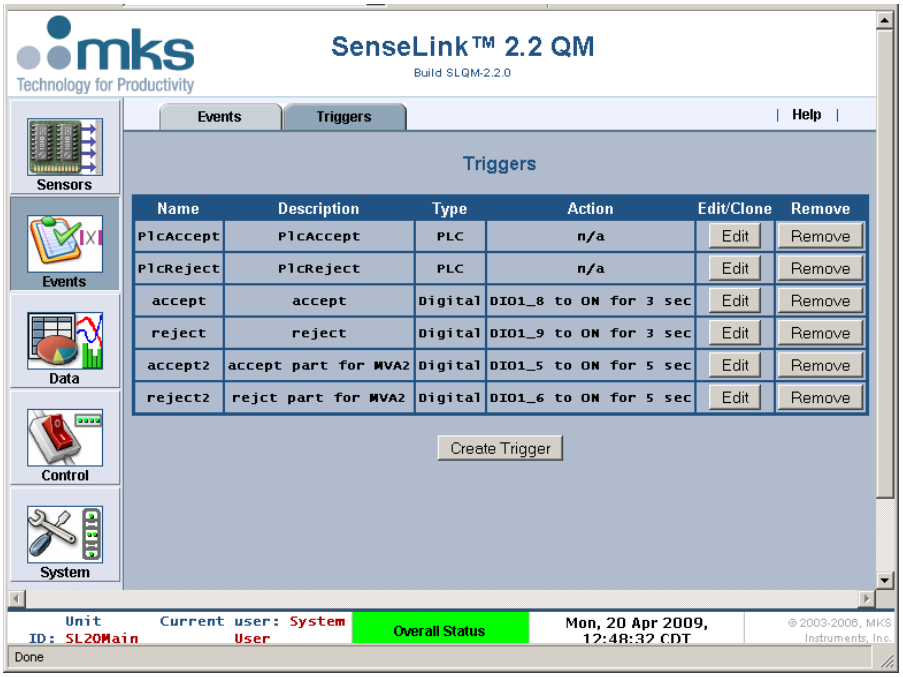


Figure 81 Creating/Editing/Removing Triggers

Select ***Create Trigger*** and the following window displays. Enter the name of the trigger, the description, and type, then select ***Next***. Then configure the trigger with an action and select ***Save*** when complete.

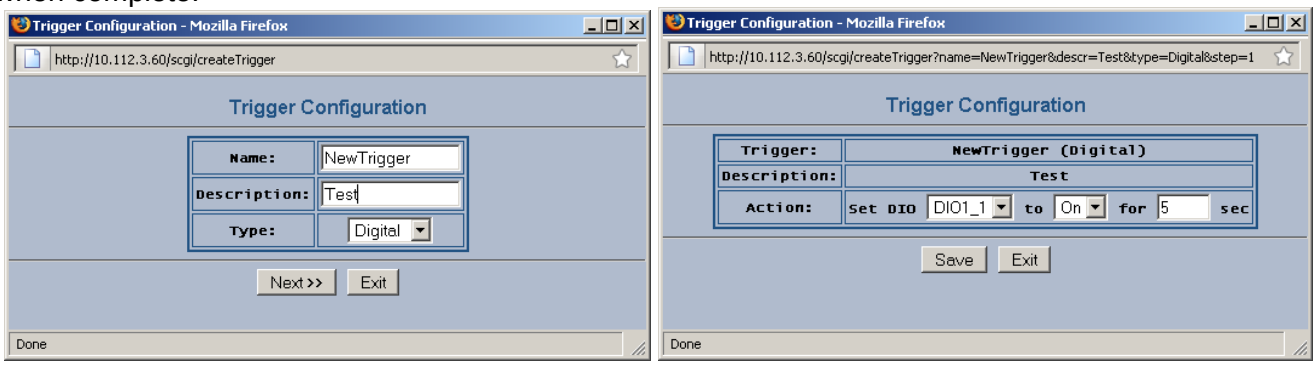


Figure 82 Creating New Trigger

6.3 Data Overview

The main Data tab displays the Traces, MVA, MVA Report, and Export tabs.

6.3.1 Traces

Traces are collection plans that define how, what, and when data is monitored and stored. By default the DataCP collection plan is setup as the modeling collection plan with only virtuals selected and the Test collection plan is setup for viewing of raw analog and digital signals. Collection plans can be

created, edited, charted, and exported for analysis from the Trace Window. Select ***Create*** to enter a new collection plan.

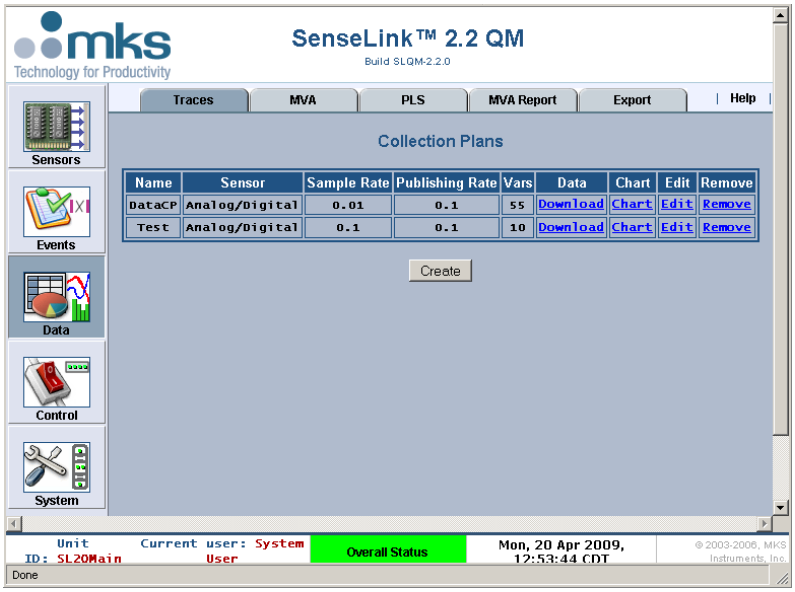


Figure 83 Creating Collection Plans

Enter the collection plan name, sensor, sampling rate, and publishing rate and select ***Next***.

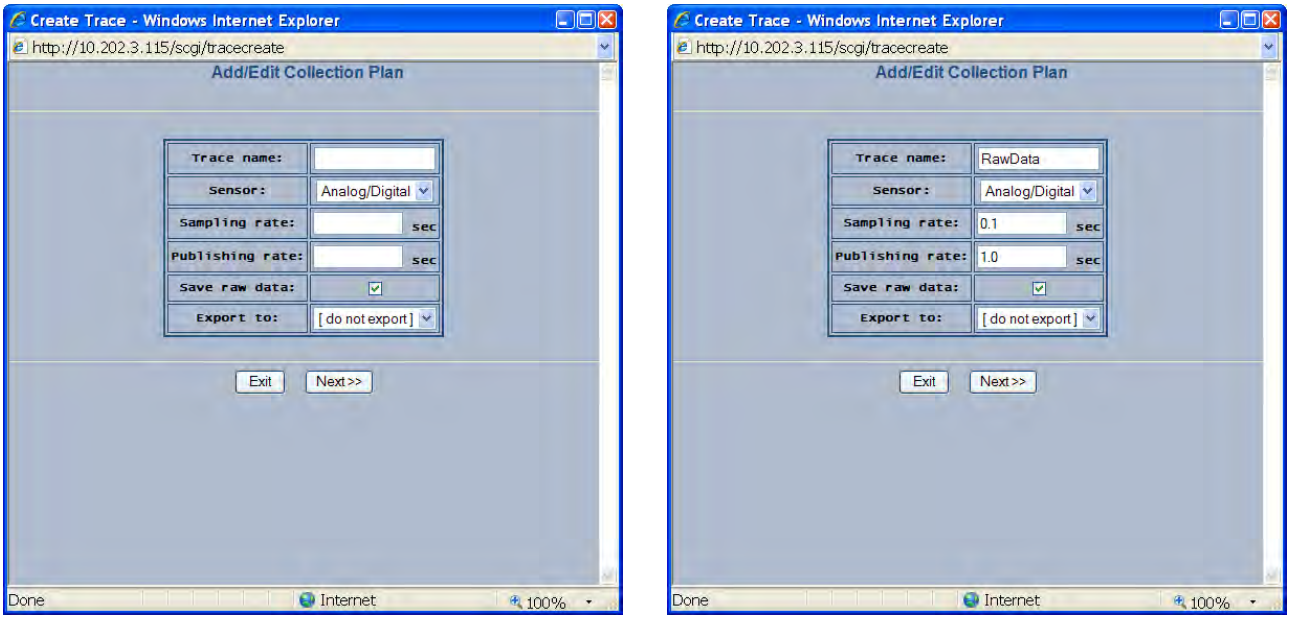


Figure 84 Creating Collection Plans

Select the virtual, analog, and digital signals that need to be monitored during the data collection and modeling and click on the single arrow key, then select ***Save***.

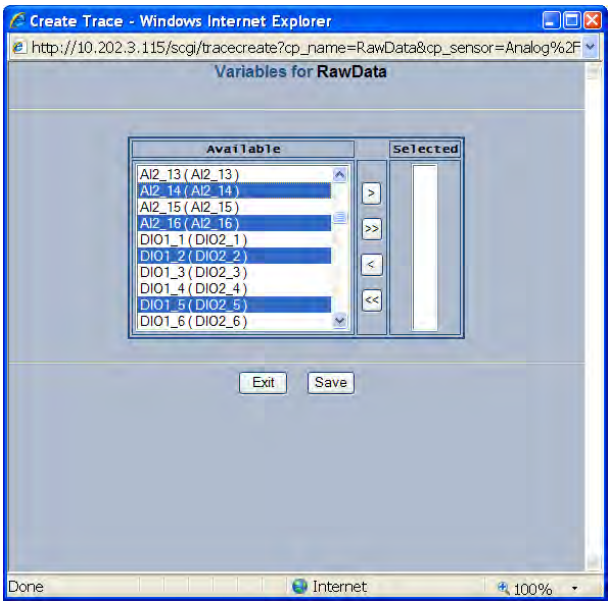


Figure 85 Selecting Variable to Analyze in Collection Plan

Then select ***Chart*** to graph the data. While the machine is idle, the signals should not be changing and should look like the following the chart. Unselect ***Check All*** to clear the screen then select only the variables that you want to observe.

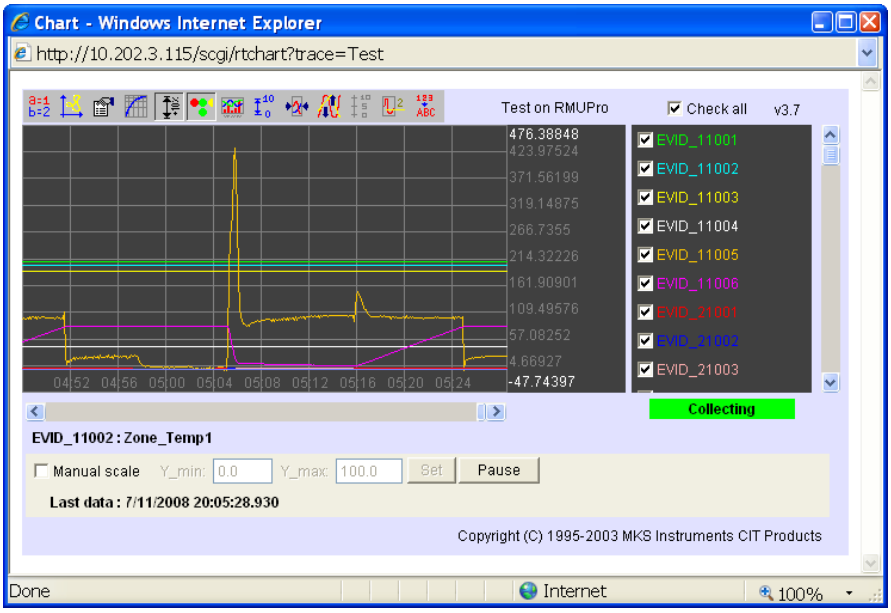


Figure 86 Graphing the Data

Selecting the ***A=1/B=2*** button  in the top left corner will create a chart showing the actual values of the signals and can be seen below.

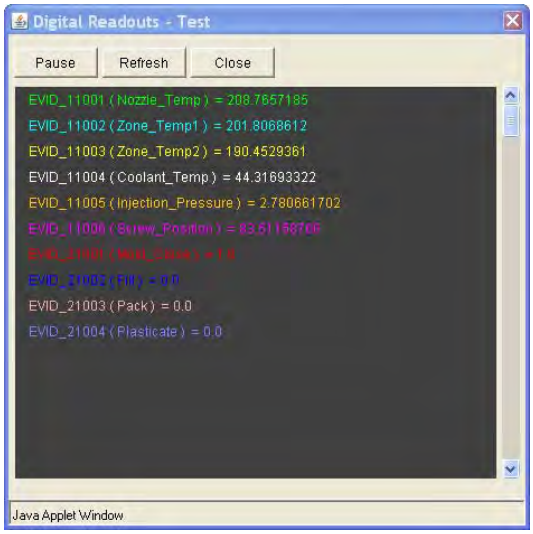


Figure 87 Signal Readouts

6.3.1.1 Creating and Editing Traces

Creating or editing a trace allows new or existing collection plans to be defined. In the ***Edit*** or ***Create*** window collection plans are defined and parameters are selected.

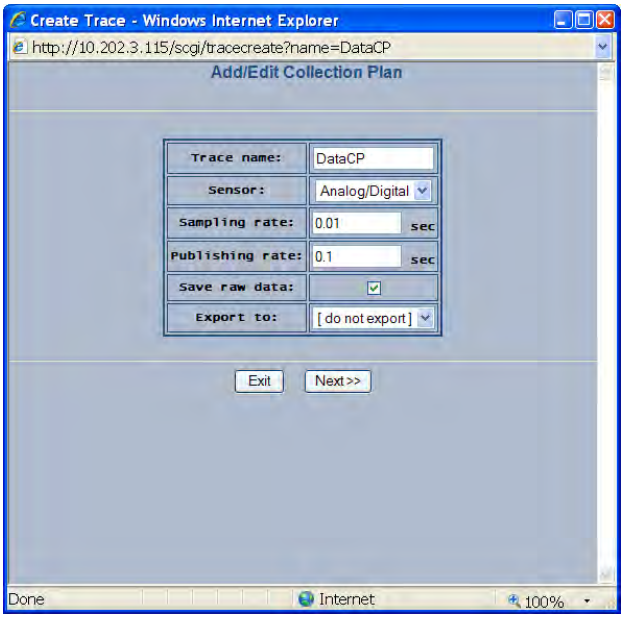


Figure 88 Creating Collection Plans

When creating a trace the collection plan is named, and a publishing and a sample rate are defined. The publishing rate is how many samples per second are saved. The value that is stored is the last sample that was read per second. The sampling rate is the number of data readings taken per second. The reason for having a separate publishing and sample rate is to allow more sampling to reduce the likelihood of missing an event and to save storage space for long term data collection. By default the sampling rate is set to 10 ms and the publishing rate to 100 ms. It is recommended to set the publishing rate to 0.25 s.

CAUTION 

Removing a trace will impact the data collection done by a TOOLweb tool side client.

6.3.1.2 Charting Trace Data

Charting data allows the user to see plots of the values for analog, digital, and virtual inputs.

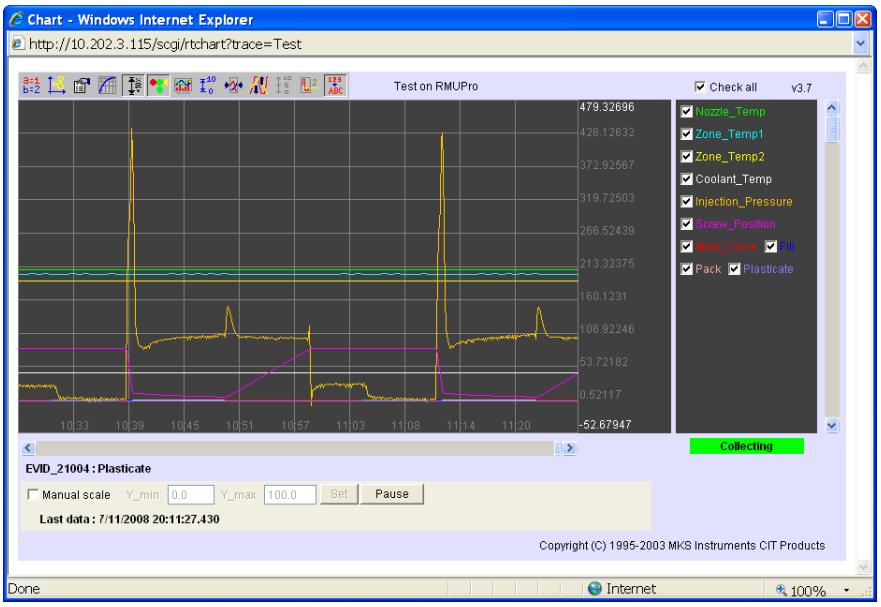


Figure 89 Charting Collection Plan Data

The chart applet has a tool bar to provide customization and aid in the analysis of the inputs.

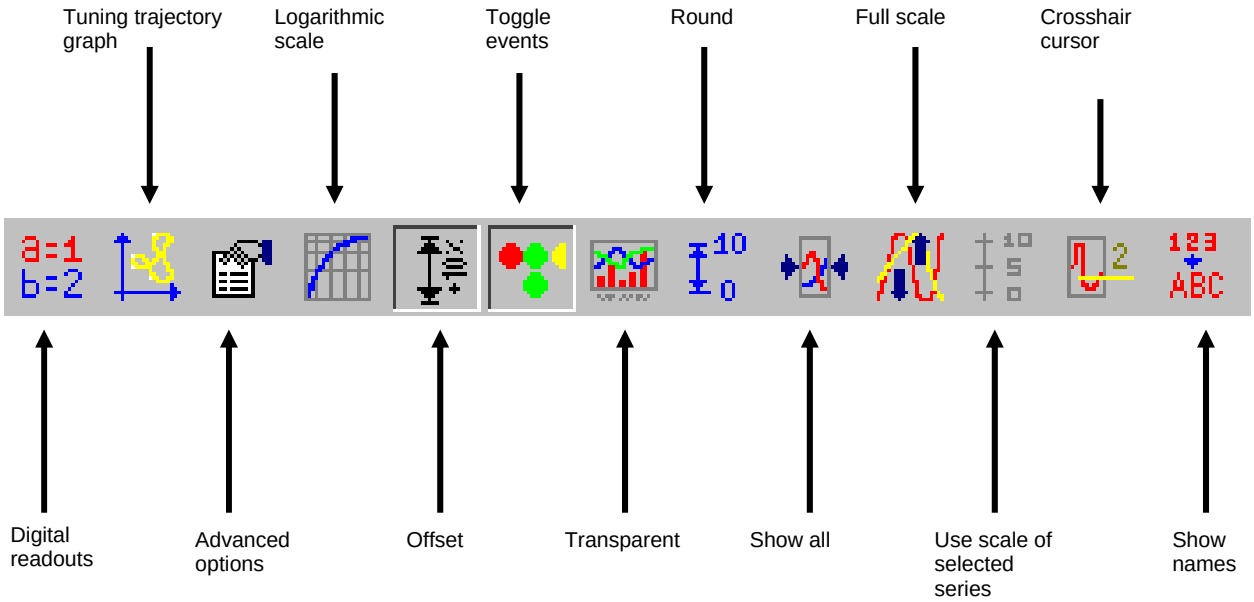


Figure 90 Charting Options

Zoom	The charting provides one level zoom functionality. To move in, move your mouse in a rectangular mode over the chart. If you select manual mode, and define the Y range, you can only scale X by zooming in. To zoom out, click on the chart.
Manual Scale	Check manual scale to define the minimum and maximum of the Y-axis. The entry will be valid for all scale units.
Pause	Check pause to stop the chart from moving.
Digital Readouts	Here the collected inputs are listed in realtime, which means that the values are changing according to the sample interval. Press the pause button if you want to stop the values from changing.
Logarithmic Scale	Check logarithmic scale to recalculate the graph. The lowest values will be scaled the largest.
Offset	Check use offset to have a free space of 10% below and above the graph. If you uncheck use offset, data points will be displayed directly on the x- axis
Invert Background	Check invert background if you want to change the background color from black (default) to gray.
Round	Check *round* to round the scaling
Advanced Options	Press *advanced* to customize the graph, select a parameter from the drop down menu and adjust as you like
Show All	Check *show all data series on one screen* to all buffered data on one screen.
Transparent	Lines will be displayed transparent.
Full scale display	Full scale means that all series are scaled to fit the screen vertically
Show Names	Show series names instead of numbers
Crosshair	Shows the crosshair cursor, displaying X-Axes and Y-axes values
Trajectory Chart	Opens a new window for the tuning trajectory chart.

6.3.1.3 Downloading Trace Data

Exporting trace data provides flexibility for data extraction from the SenseLink™. The data is stored in a ring buffer always keeping current data. Once the buffer is full the oldest data is discarded. When exporting data, the time window and format of the data is selectable.

The start and stop time can be modified if specific data is required. The Export Window allows the format for charting applet, CSV (Excel\spreadsheet format), and plain comma delimited text, and will store up to 40 MB of data.

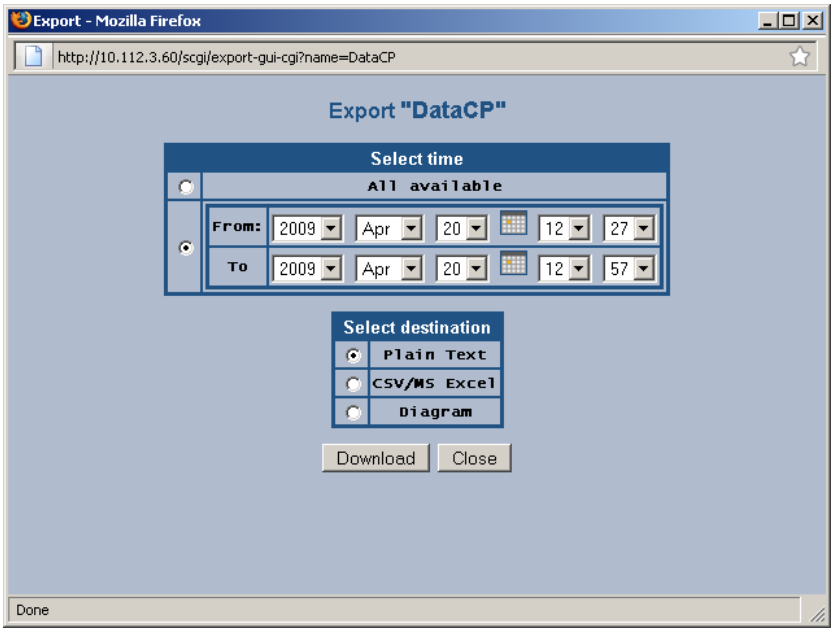


Figure 91 Exporting Data

6.3.2 MVA

Selecting the ***MVA*** tab will bring up the main SenseLink page. From this page, any previous data can be downloaded and displayed on the MVA target, displaying what parts are in and out of spec based on the current running model.

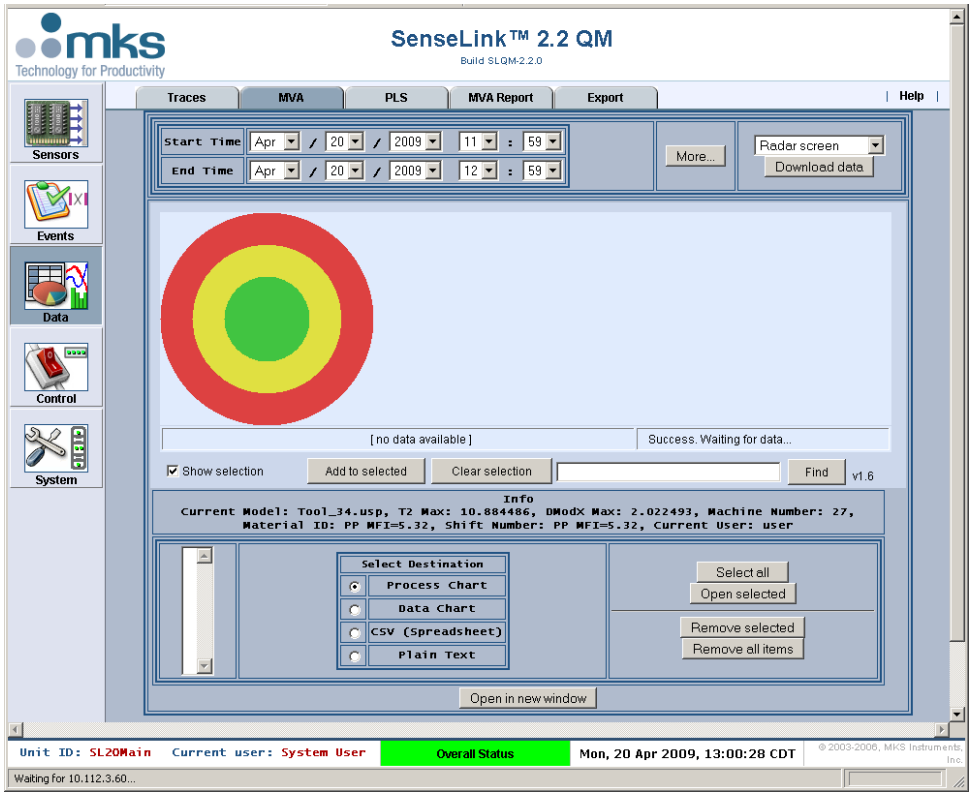


Figure 92 SenseLink MVA Main Page

Once the ***Data/MVA*** tab is open, data will update on the radar screen in real-time, just as the cycle is complete.

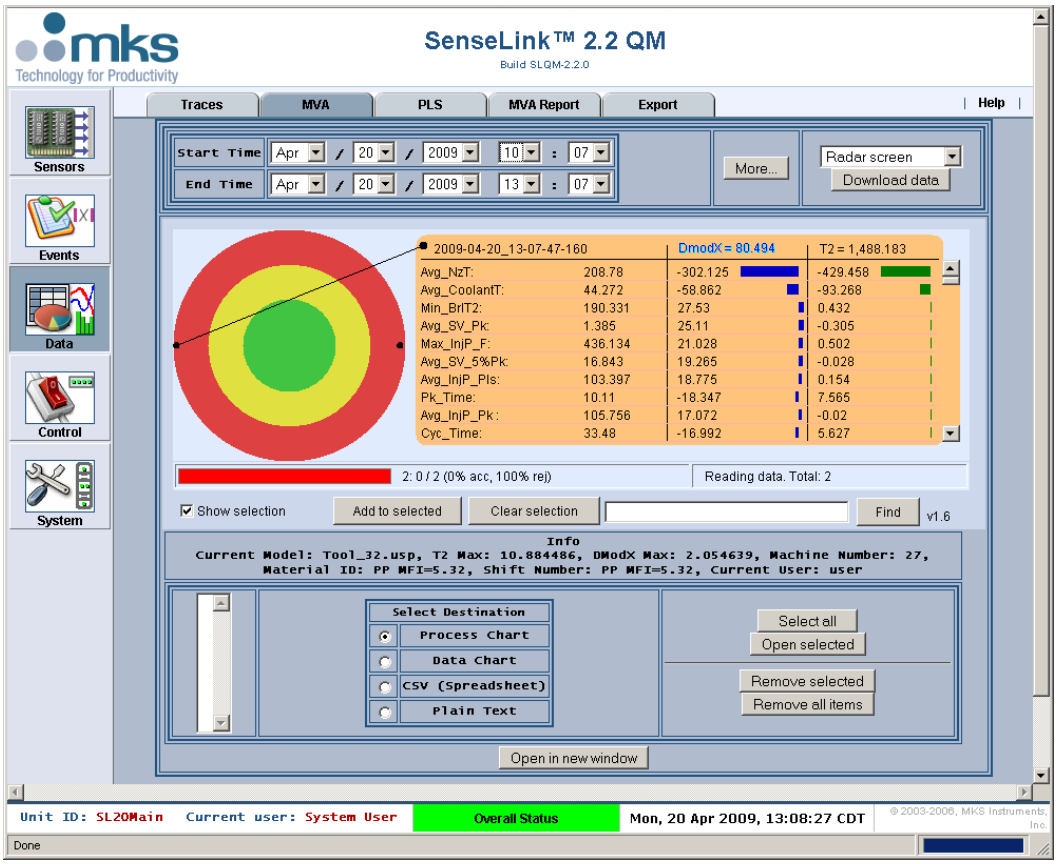


Figure 93 Data Updating in Real-Time

Also, a processing time frame can be chosen and the data is downloaded; the data appears on the target where each dot represents one molded part. Any parts that show up in the red area are outside of the set MVA limits and will be automatically rejected. The plot next to the target represents a contribution plot which calculates the MVA summary statistics for each variable and determines the data feature or variables responsible for the process variation.

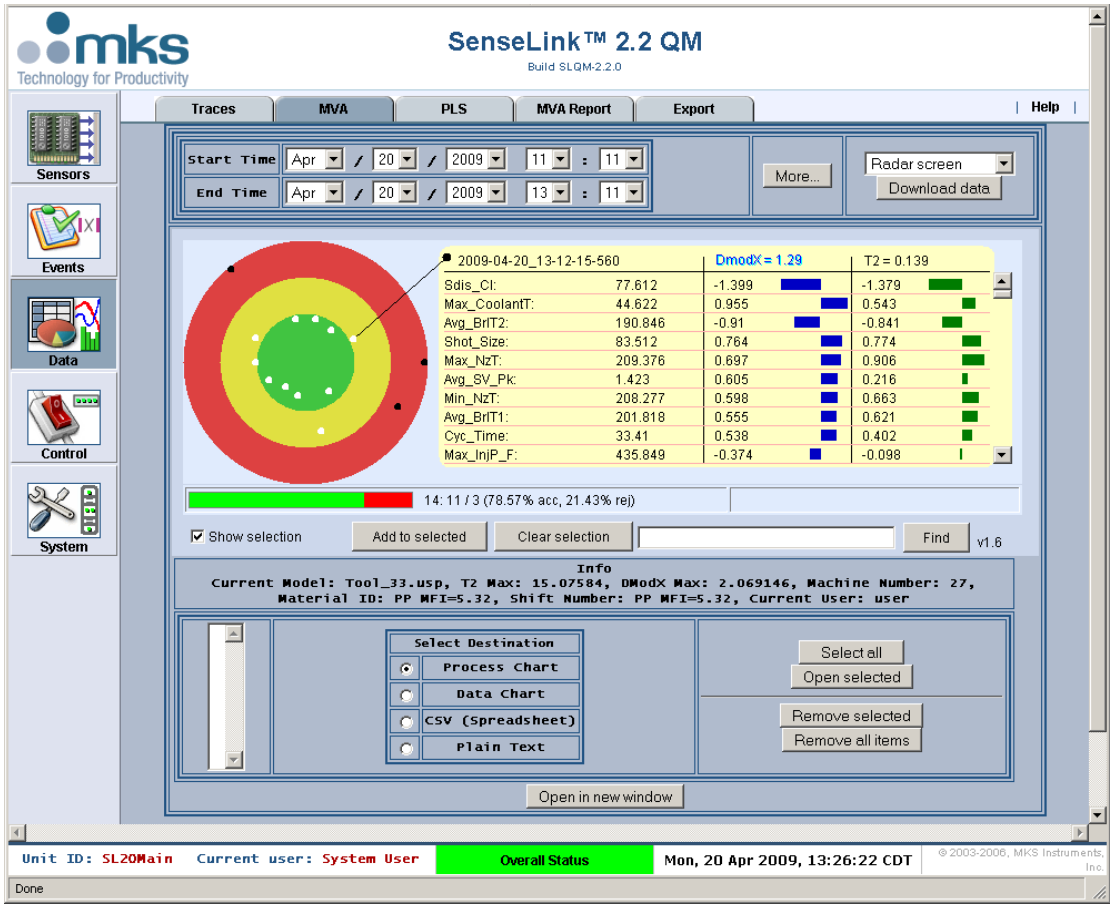


Figure 94 Real-Time Part Evaluation

6.3.2.1 Downloading Summary Data

Under the MVA tab, cycle summary data can be downloaded onto the radar screen, onto a data chart, into a .csv file, or into a text file. This can all be done be done by selecting the drop down arrow above the Download Data button shown below. The data downloaded here will display both the values of each of the selected inputs along with all of the MVA statistics, as opposed to downloading data from the Traces tab which only displays the input values.

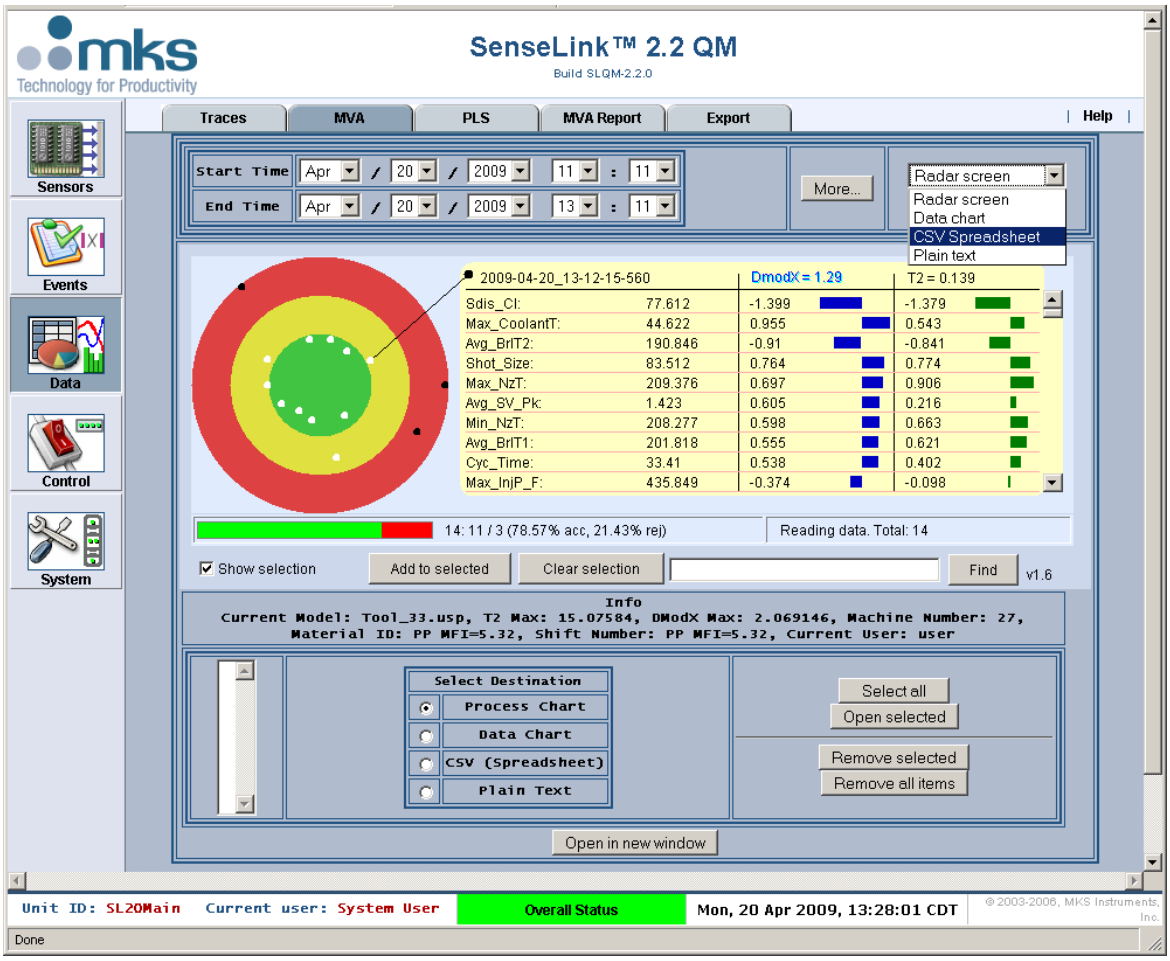


Figure 95 Downloading Summary Data

6.3.2.2 Downloading Raw Data

Under the same MVA tab, raw data can also be downloaded. Select specific points or parts of interest and select the ***Add to Selected*** button. The parts are then displayed in a table in the bottom left. You must then select the ***Select All*** button to highlight the parts. The user then has the option to examine the data in a Process Chart, Data Chart, CSV Spreadsheet, or Plain Text by selecting the data method and selecting ***Open Selected***.

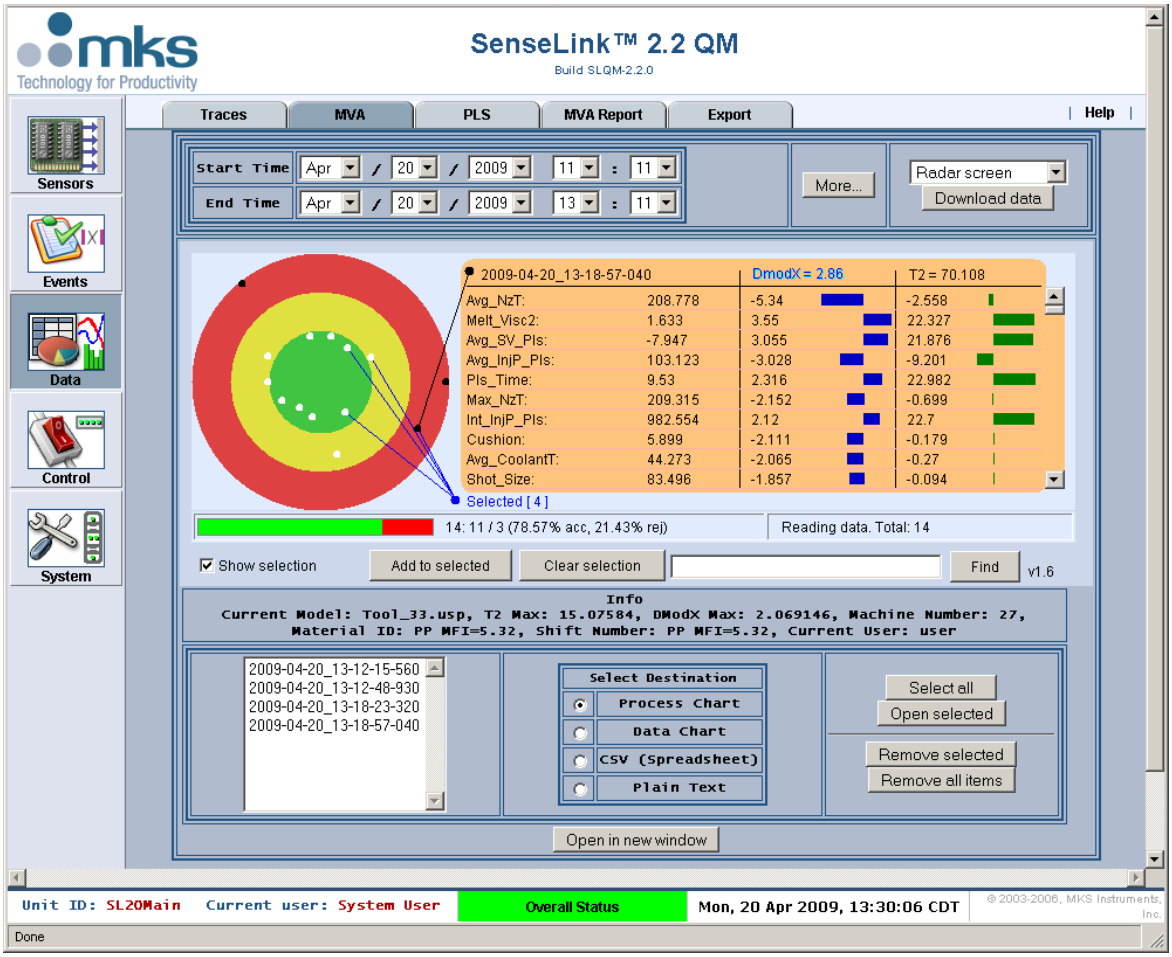


Figure 96 - Downloading Raw Data

Selecting Process Chart will allow the user to examine multiple parts and view the individual traces of each cycle. This option also gives the user the ability to overlay traces from a specific cycle over other cycles.

6.3.2.3 Overlaying Traces from Different Cycles

Traces from different cycles can be overlaid on a chart to allow the user to do a direct comparison. If a data cycle is found to be in the red zone on the radar screen it may be useful to:

1. find the variable with the largest DmodX or T^2 value
2. select another point in the green zone on the radar screen
3. overlay traces of the variables from the two cycles to view differences.

Multiple points can be selected from the radar screen by clicking on the points.

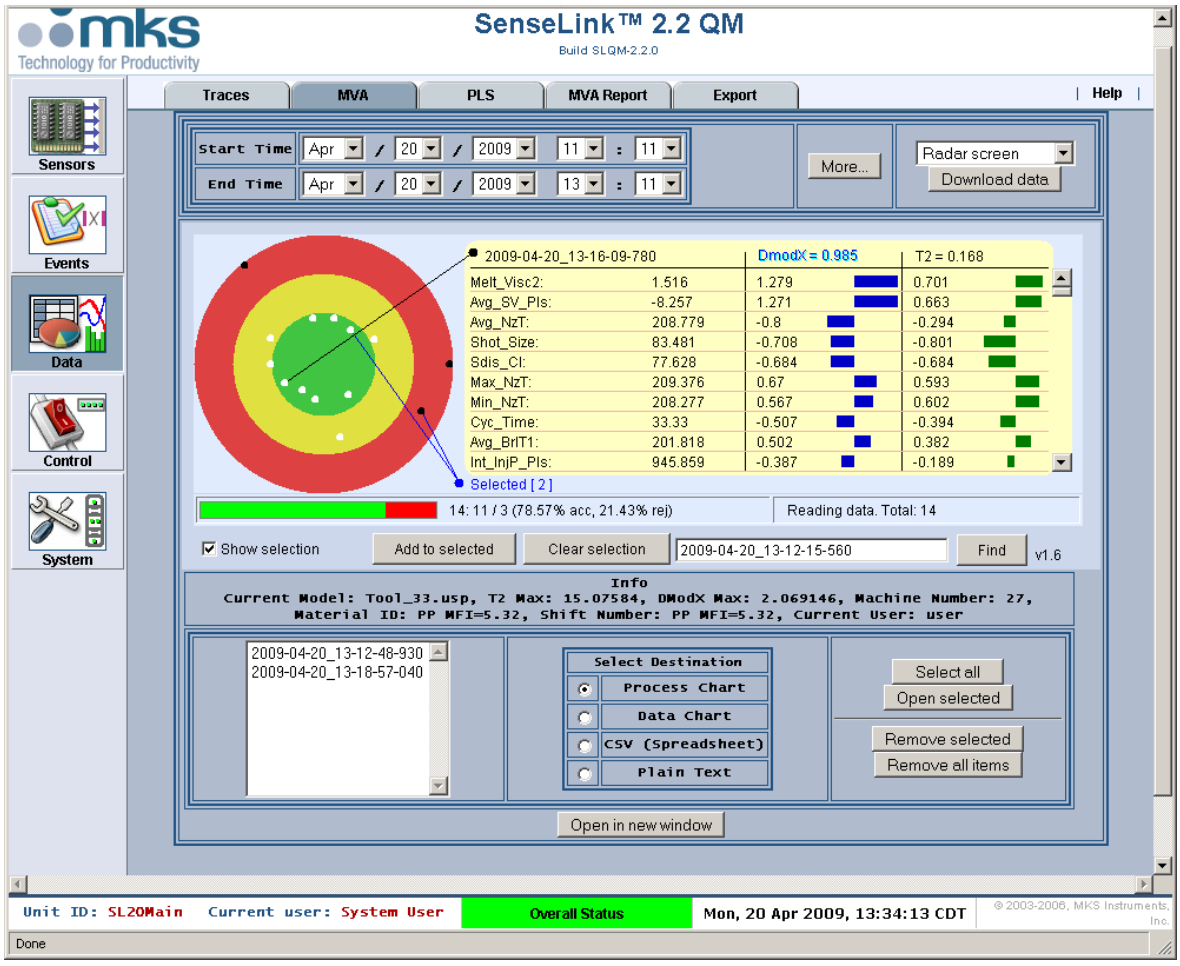


Figure 97 – Select Data to Compare

Once the points (cycles) are selected from the radar screen, click the ***Add to selected*** button. This will display the selected cycles in the bottom left corner.
To view the data, select ***Process Chart***, then click the ***Select all*** button followed by the ***Open selected*** button.

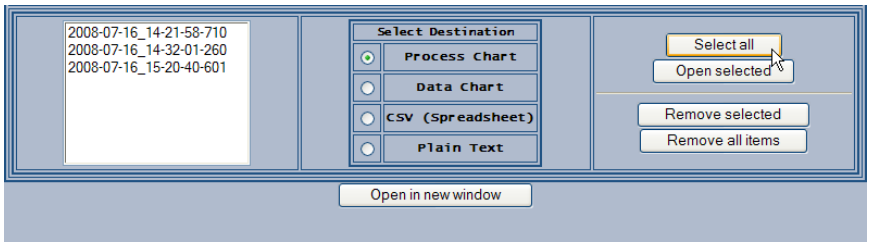


Figure 98 – Selecting and Opening Selected Data

If 3 cycles were selected then a screen will be displayed showing all of the data on 3 graphs. (The number of graphs loaded will be determined by the number of data cycles selected by the user).

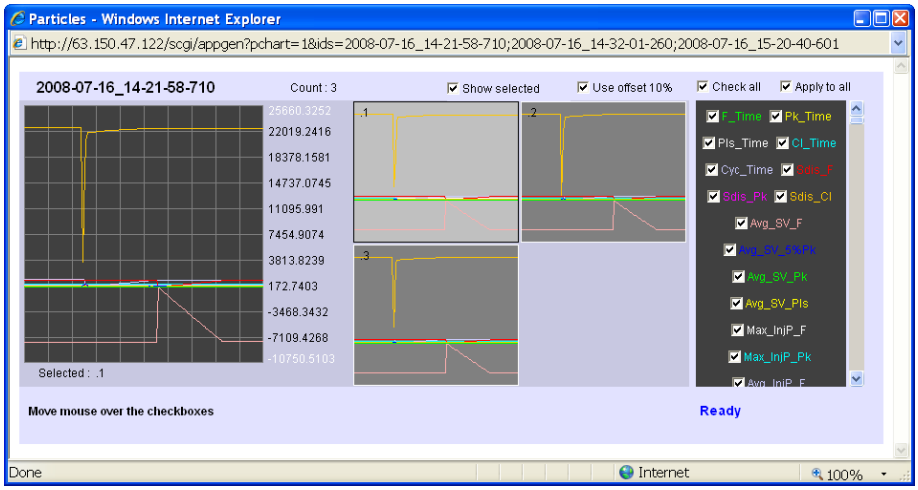


Figure 99 – Selected Traces

Deselect the ***Check all*** box to clear the traces.

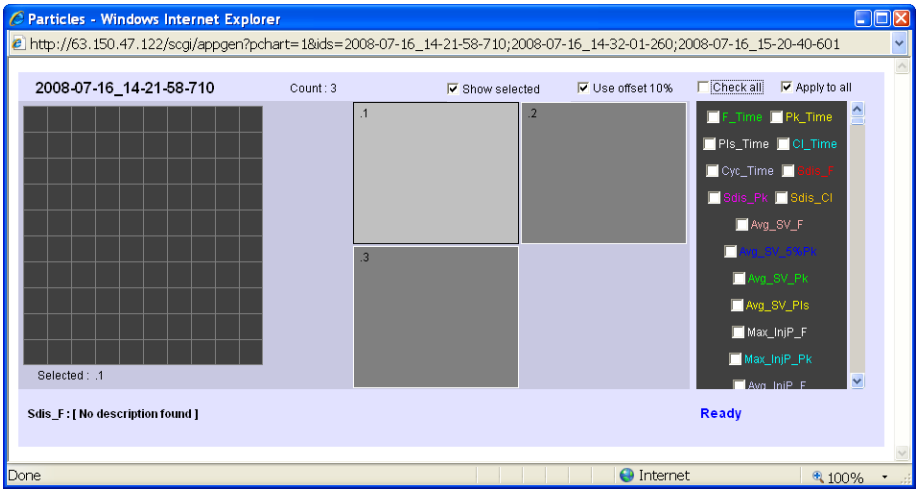


Figure 100 – All Traces Cleared

After clearing the traces choose only those variables that are to be overlaid. Ensure that the following boxes are selected:

- ***Show selected***
- ***Use offset 10%***
- ***Apply to all***

The traces chosen will appear on the respective charts on the right hand side of the screen. The Overlay chart is on the left hand side of the screen and must be cleared before traces can be dragged over.

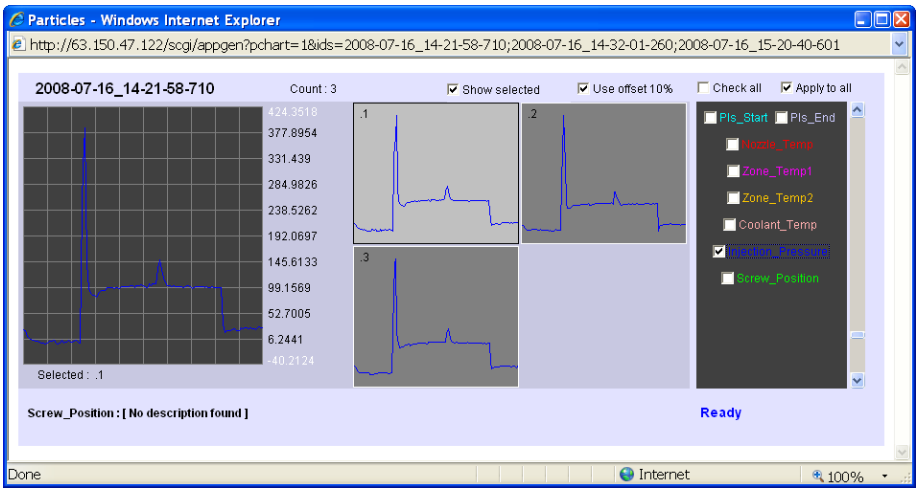


Figure 101 Selecting only relevant variable(s)

Clearing the traces to allow for overlay is done by deselecting the ***Show selected*** box.

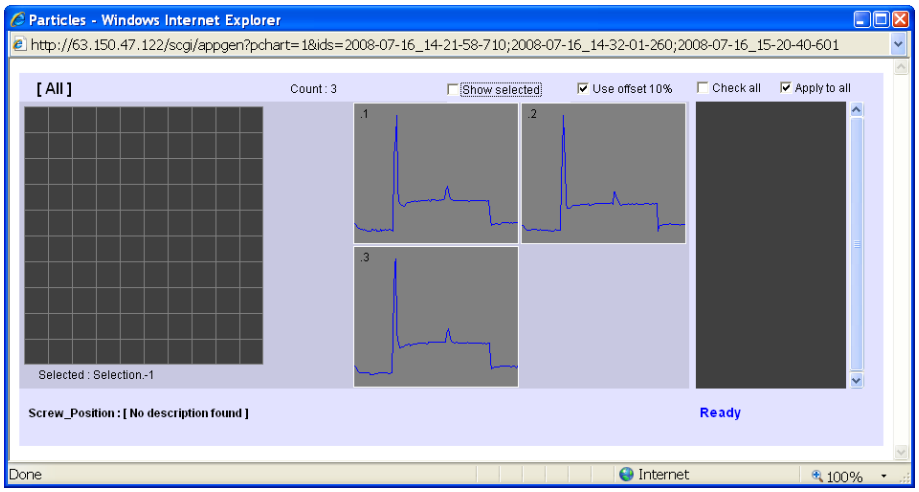


Figure 102 Settings to allow for drag and drop of traces

Now the overlay chart is clear and traces from the charts can be dragged over by clicking the mouse on the trace and dragging it to the overlay chart on the left hand side of the window.

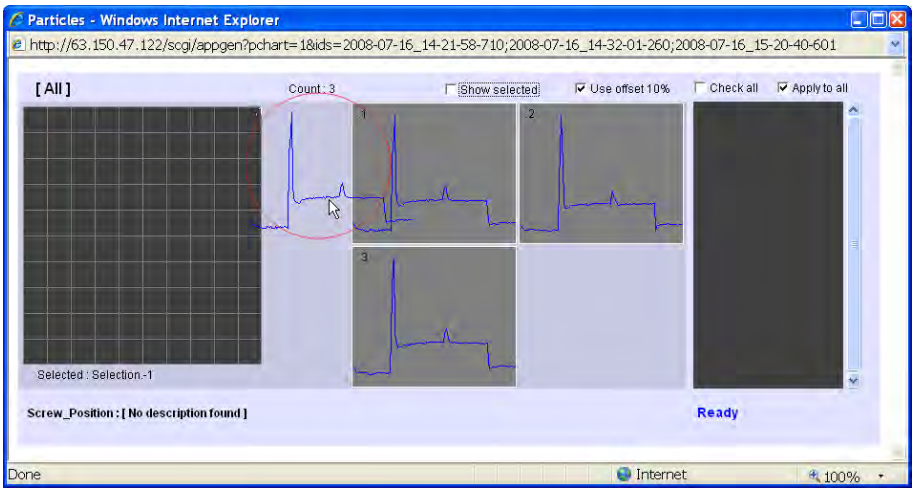


Figure 103 Mouse click trace and drag to grid

Once the traces are all dragged on the overlay chart the user can then view the differences in the traces.

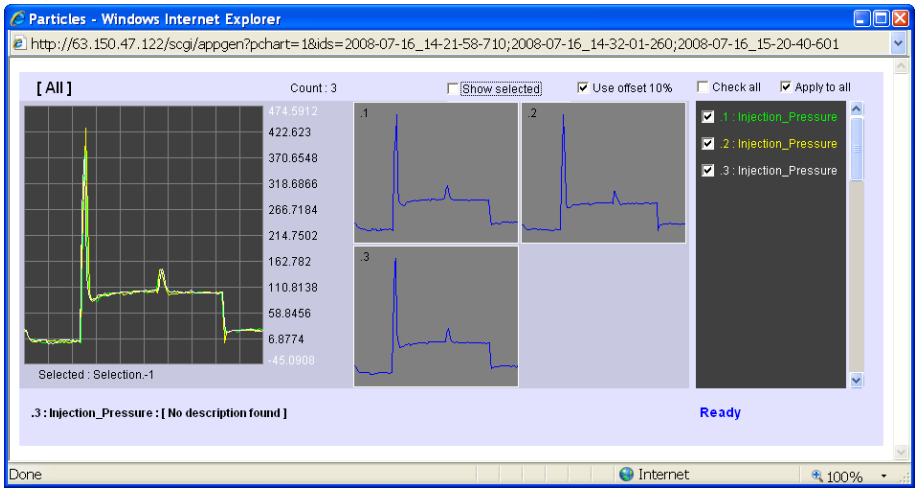


Figure 104 After all traces have been dragged to grid

To zoom into differences on the overlay chart using the mouse, click on the overlay chart and draw out a rectangle.

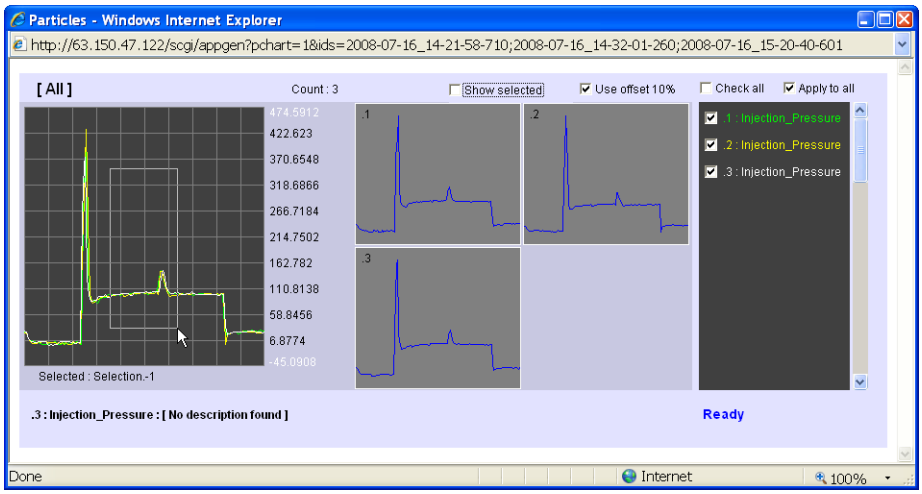


Figure 105 Selecting zoom region on Overlay Chart

Releasing the mouse will show a zoomed view of the chart.

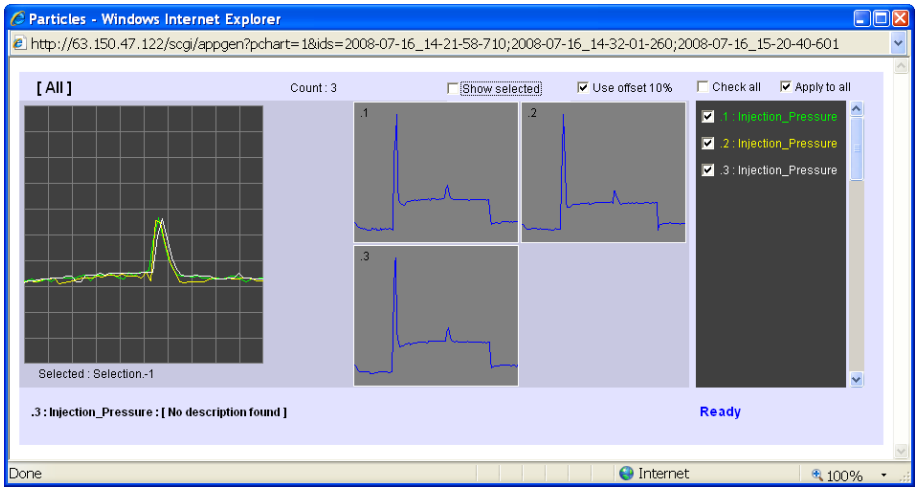


Figure 106 Zoomed in region on Overlay Chart

Mouse clicking anywhere on the overlay chart again will restore the normal (non-zoomed) view.

6.3.3 PLS

The PLS tab allows the user to view data that results from a PLS model. In order to create a PLS model, Y variables or quality attributes must be manually added to the model and built in SIMCA P+. The quality attribute data can either be added into an excel file of existing process data and then built in SIMCA or it can be added directly to the USP file. The names of the Y variables cannot contain any spaces or symbols but can be named anything and multiple Y variables can be included. Some Y variables might include Weight, Thickness, Length, Defect_Type, Short_Shot_Length, etc.

Once the PLS model is activated in the SenseLink QM, the data can be viewed from the PLS tab. As each cycle finishes, a dot will appear on the chart which represents the latest cycle. Each of the Y variables can then be selected to view their predicted values, in the top right area of the contribution table. If the values are out of spec, the contributing factor can be observed from the contribution chart, with the most root cause of the process issue being the variable at the top of the list.

This data can also be downloaded into CSV format as well.

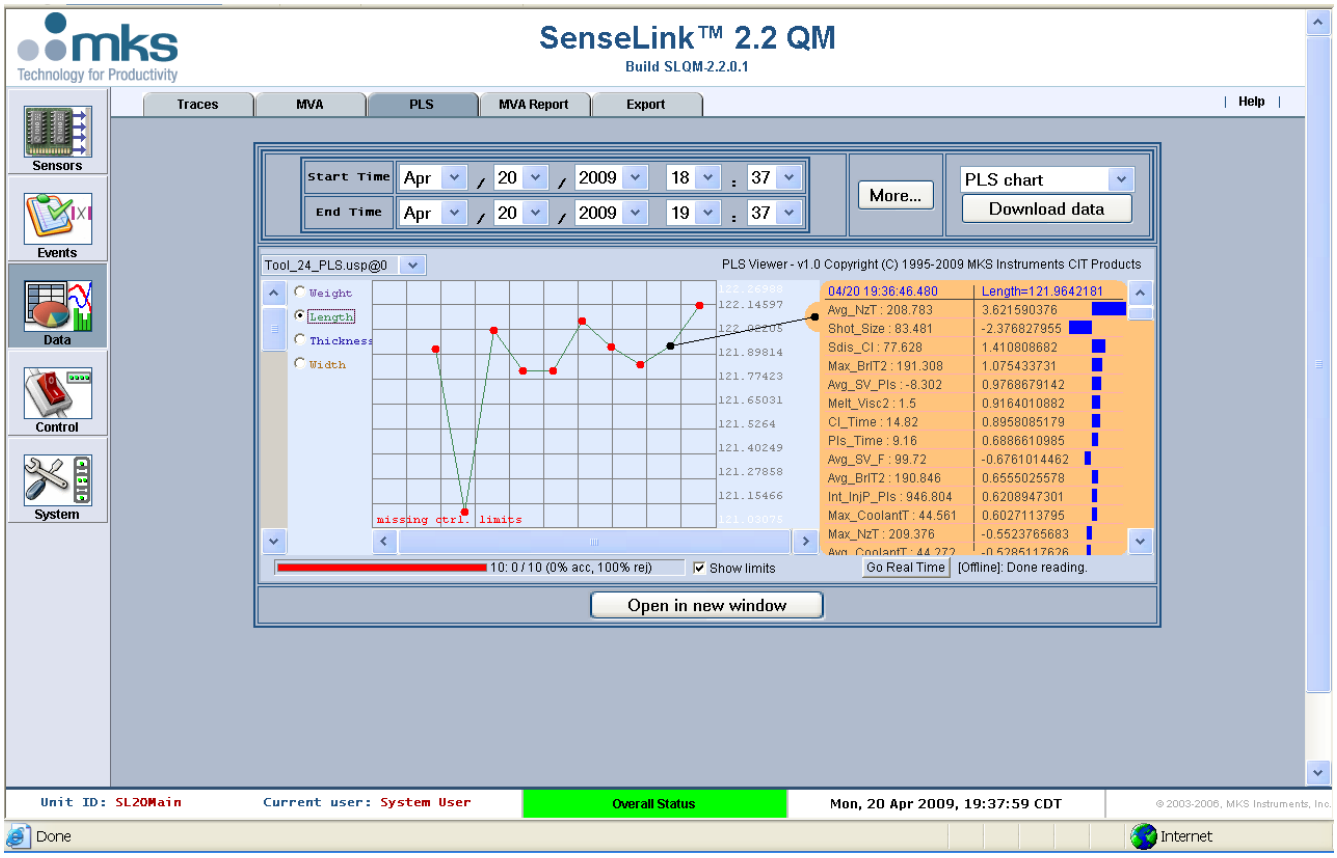


Figure 107 - Viewing PLS Models

6.3.4 MVA Report

MVA reports can then be created which give a summary of the total parts being accepted and rejected. This can be done by selecting the time frame of data needed, and either selecting ***Open Report***, Figure xx, or selecting the total efficiency or raw data export along with preferred data file.

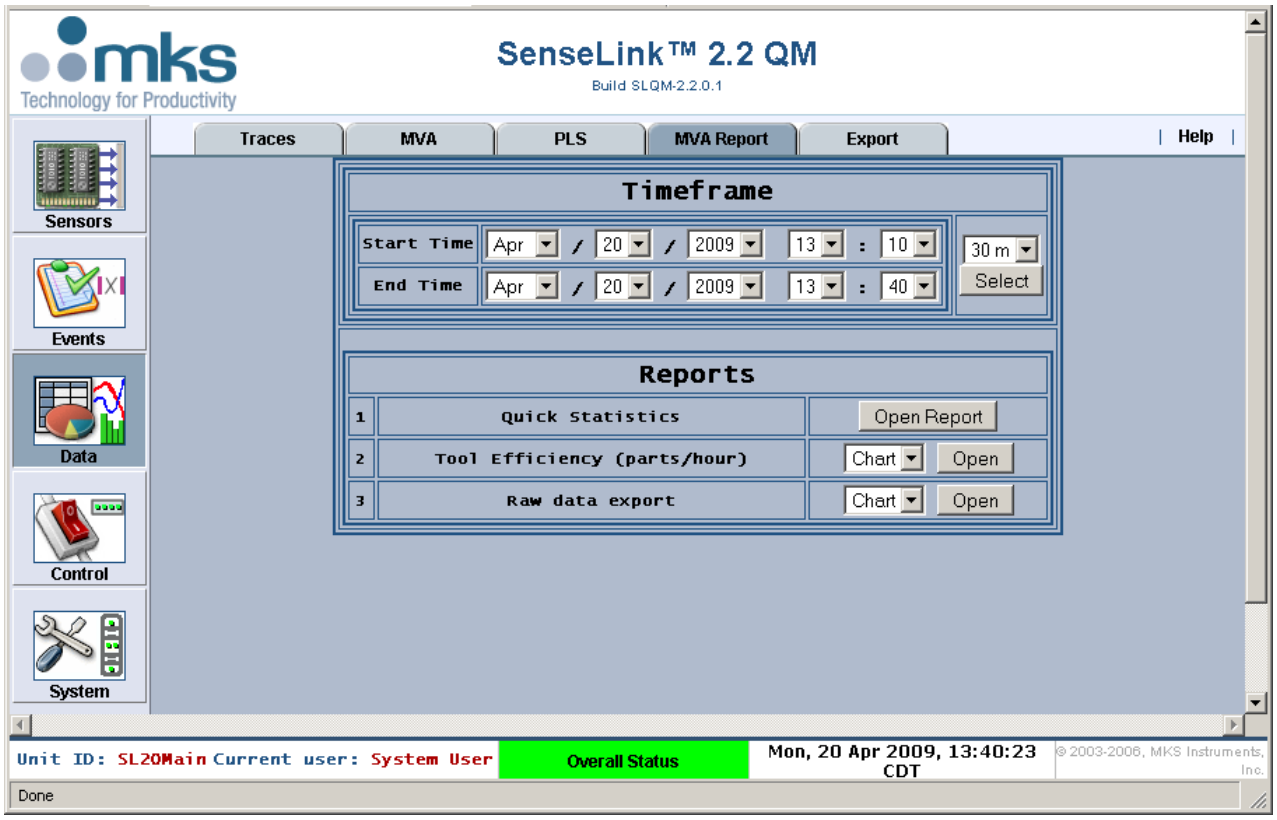


Figure 108 Creating MVA Reports

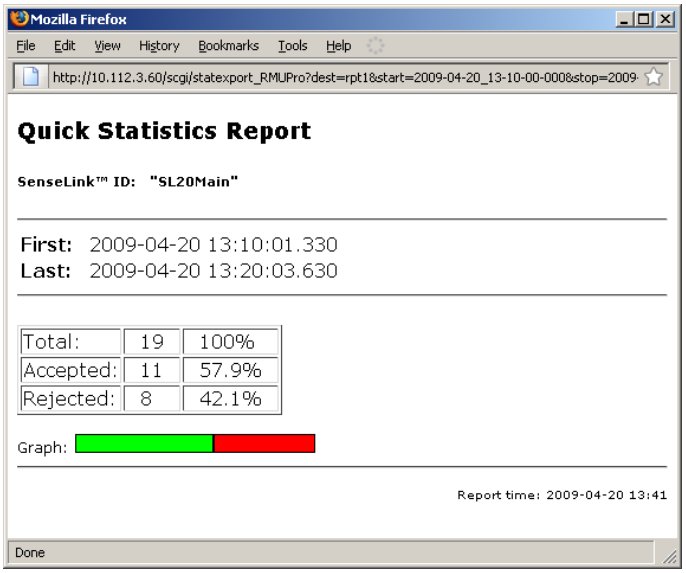


Figure 109 Quick Statistics Report

6.3.5 Export Data

Selecting the ***Export*** tab gives the user the ability to move the data from the SenseLink to another location such as a server for future analyzing or to do external data backup.

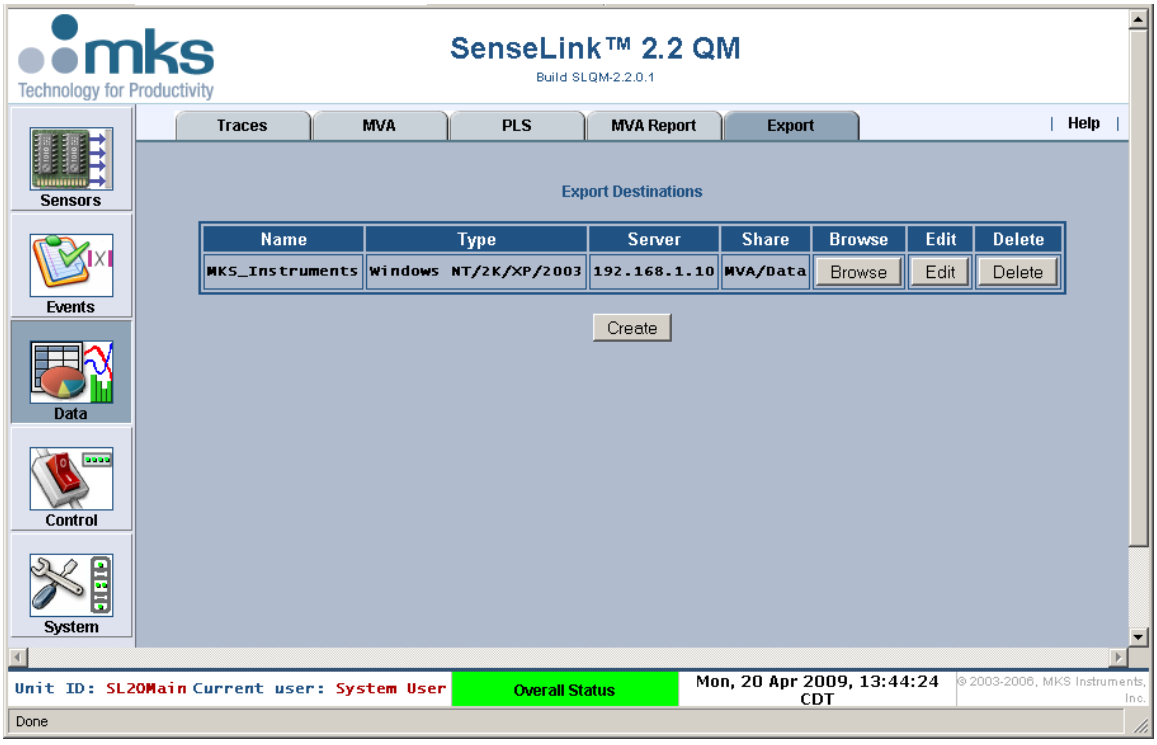


Figure 110 Exporting Process Data

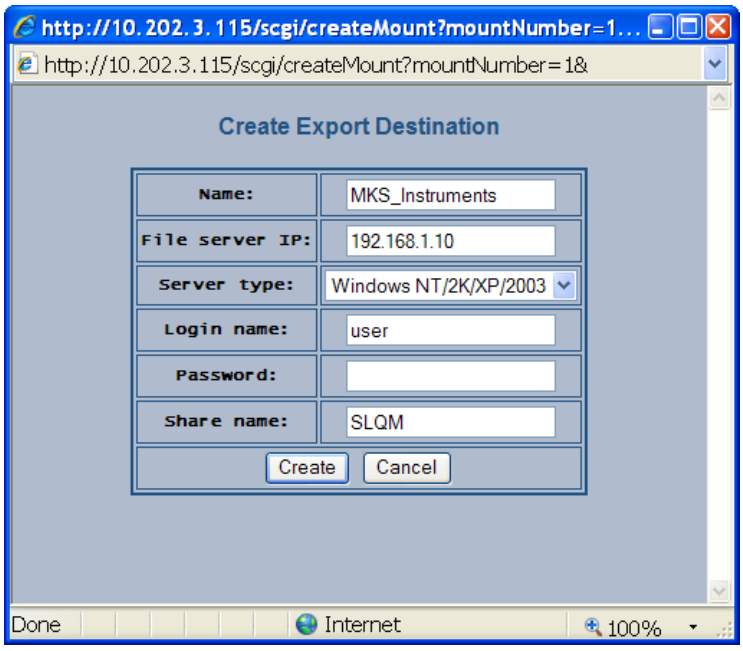


Figure 111 Data Exporting Location

6.4 Control Overview

Selecting the Controls main tab gives the user the ability to activate a model under the ***MVA Config*** tab and to run a DOE and collect data under the ***MVA DoE*** tab.

When running a DOE, name the DOE and define a time period when data is going to be collected. Then click ***Start***. The box in the right corner will no longer say idle and it should turn green, now it is collecting data.

After the DOE has been run, the data will be saved under the Data section shown below. The data can then be downloaded offline to SIMCA P+ for analysis or a model can be created online.

To create a model online, select the ***Create*** button where the data is displayed. A model is then created based on the DOE and displays under the Models section.

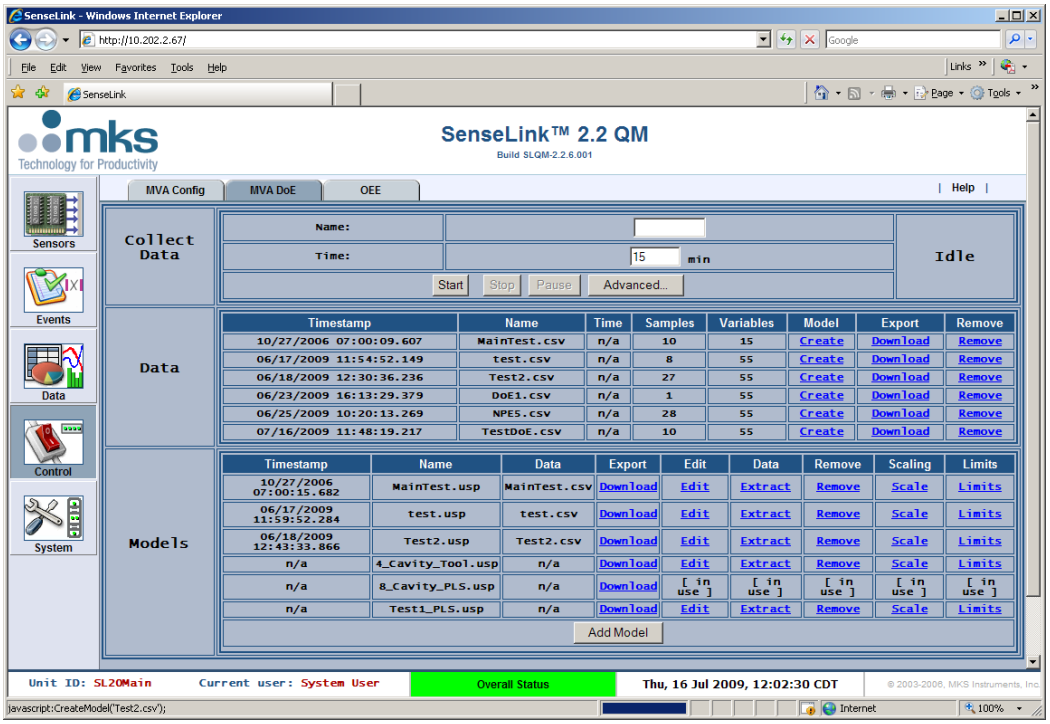


Figure 112 Creating a Model

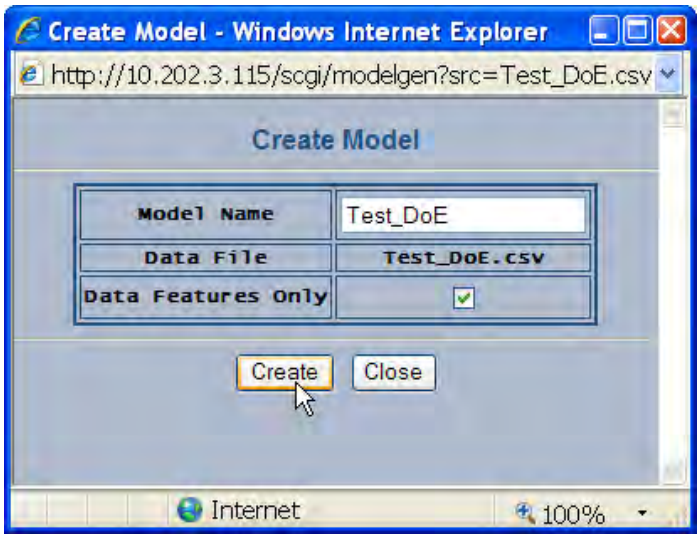


Figure 113 Model Name

Figure 114 Confirmation of Model Created

Viewing or rebuilding the model can then be done by selecting ***Edit*** model. Points can be selected or removed and the model can be rebuilt. The model is displayed as a first and second component scatter plot.

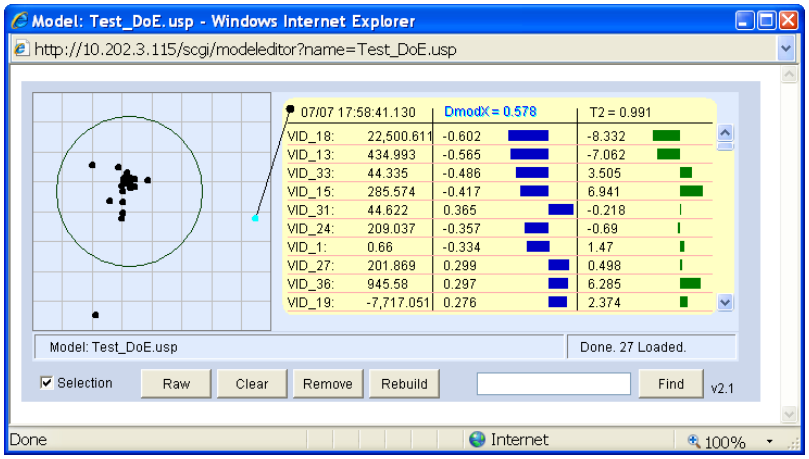


Figure 115 Viewing/Rebuilding Model

Once the model is created, selecting the ***MVA Config*** tab gives the user the ability to activate that model and set the control limits. The first step, before activating the model, is to ensure that the DataCP collection plan is selected. The DataCP should have been selected prior to running the DOE as it consists of all of the virtual or data feature inputs which the model is created from. Also be sure to select the event “Start”, as it is setup as mold open (cycle start and cycle end), for both Process Start and Process Stop. Select the triggers for Accept and Reject and also for Health DIO select the System OK digital output which by default is DIO1_10. Then select ***Activate*** to submit the changes. To activate the new model, select the model from the drop down box shown below.

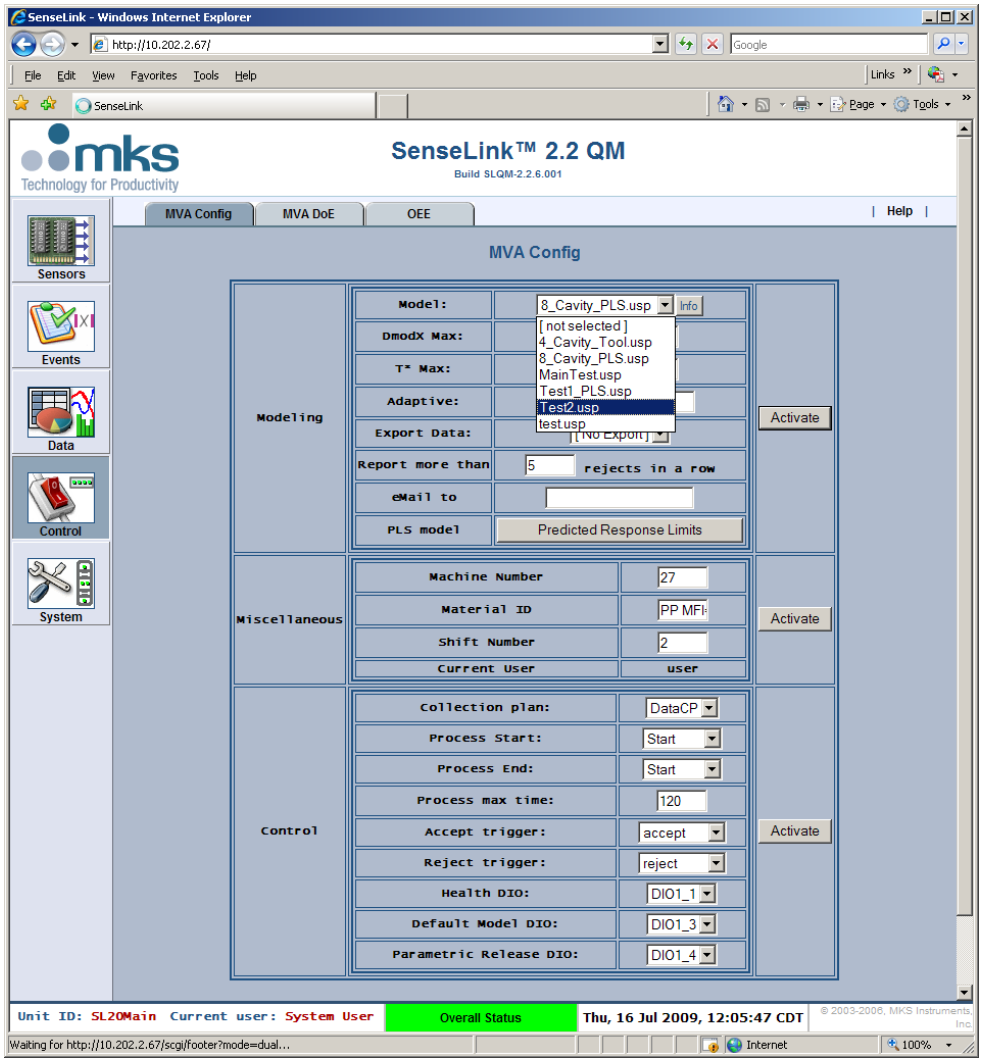


Figure 116 Selecting New Model

Then select ***Info***, which displays the statistics and suggested control limits for the model. Selecting ***Copy Limits*** will then put the suggested limits in place for the model. A validation trial is then typically done to refine the model limits if necessary. Then select ***Activate***. The new model is now comparing any new molded part data to the model. The first two to three shots following the activation of a new model will always result in rejected parts. The results of the new model can then be observed under the Data MVA tab.

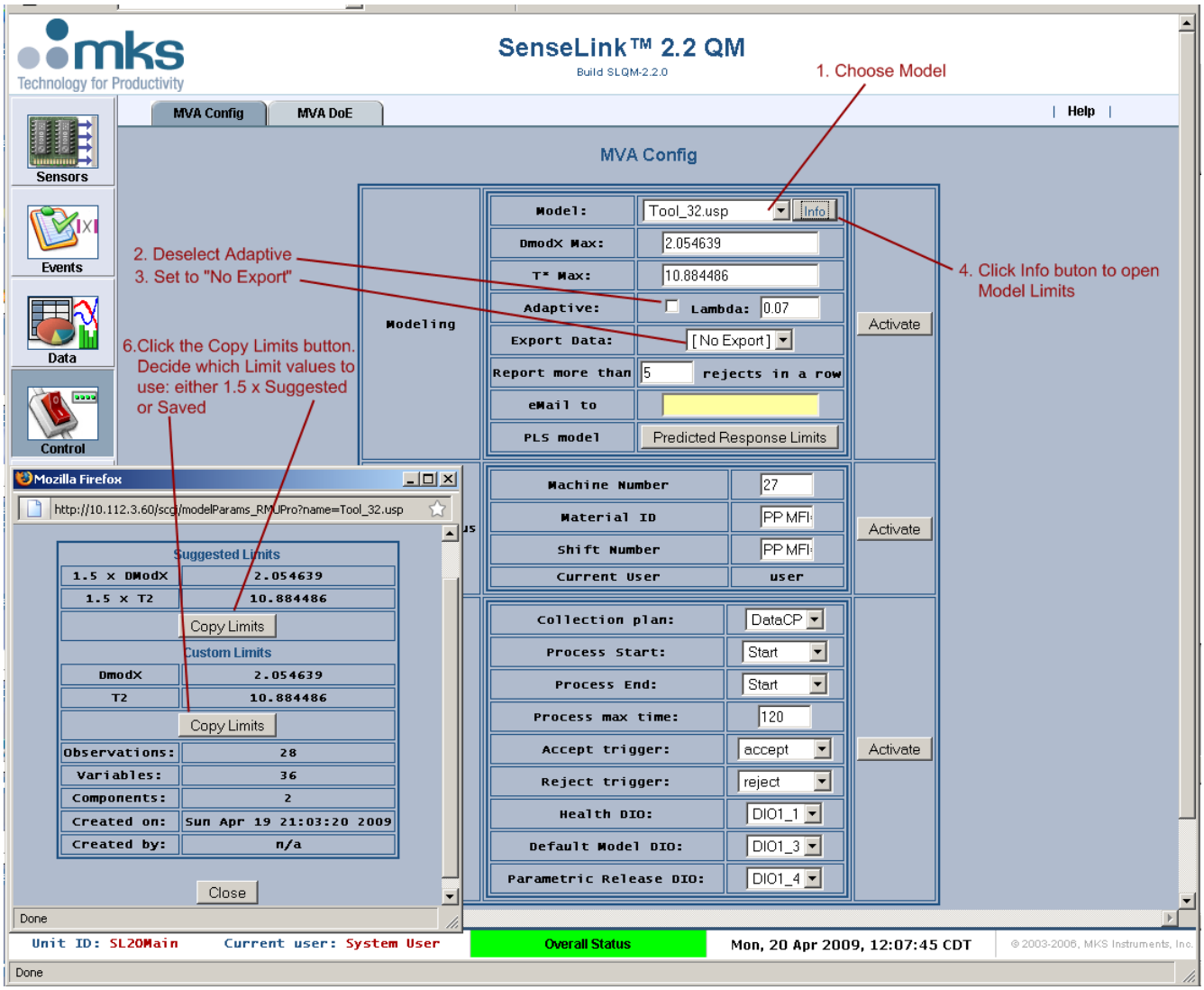


Figure 117 Copying Model Limits

In addition to selecting and activating models, the machine number, material ID, and shift number can also be modified. These inputs will then be displayed on the Data/MVA tab will appear under the radar screen.

Selecting ***Predicted Response Limits*** allows the user to set upper and lower control limits on their Y variables or quality attributes. In the example below, the part length is set with an UCL of 122, an optimum value of 121.5, and an LCL of 121. Also the boxes are checked which means that if the predicted length exceeds the UCL or LCL, the part will be rejected just as if the DModX or T2 were out of their limits.

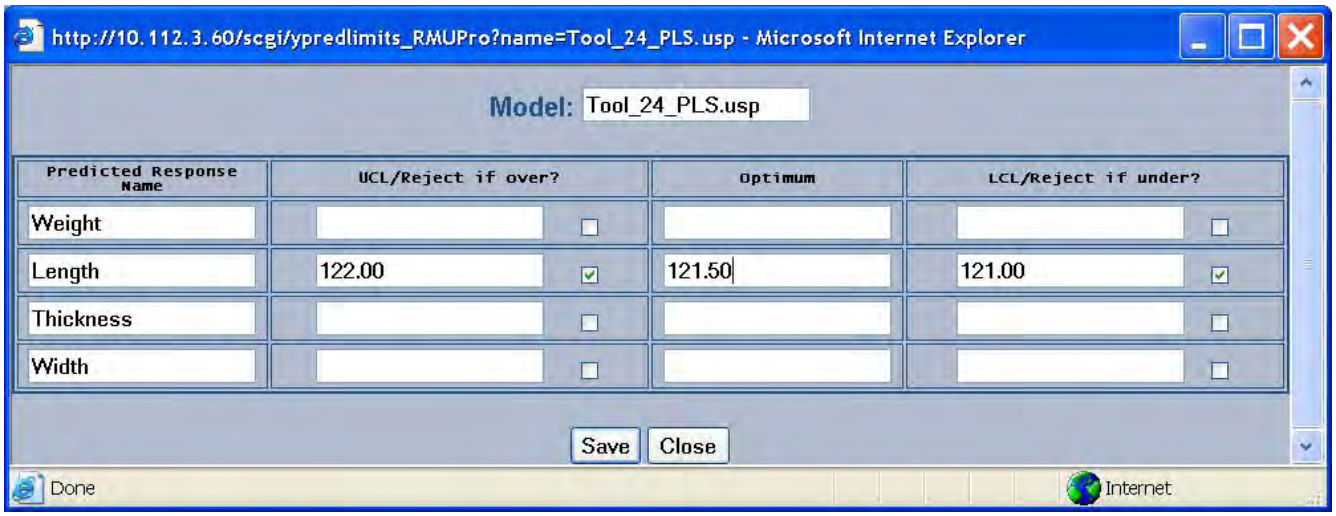


Figure 118 - Setting UCL and LCL Limits on Quality variables

Once the limits are set, they can be displayed on the PLS chart, by selecting ***Data/PLS*** and checking the ***Show Limits*** check box. The UCL and LCL are shown based on the yellow background and the optimum setpoint is the green line.

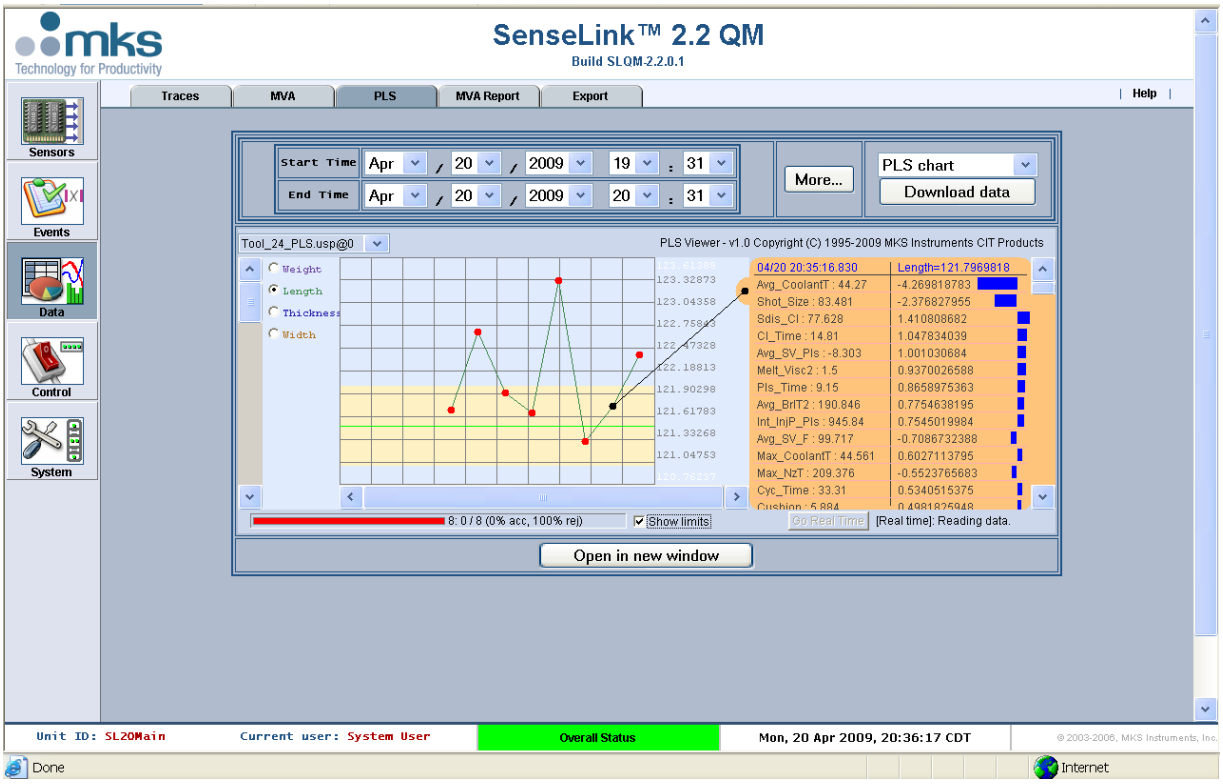


Figure 119 - Viewing UCL and LCL on the PLS Chart

6.5 System Overview

The system tab allows you to do the following:

- Monitor alarms
- Adjust network settings
- Modify date and time settings
- Add/Edit users and profile information
- Perform basic diagnostics
- Update/Export the SenseLink™ software and view the update history

6.5.1 Alarms

Alarms are displayed to represent the system health of the SenseLink, and can be found in the Alarms tab.

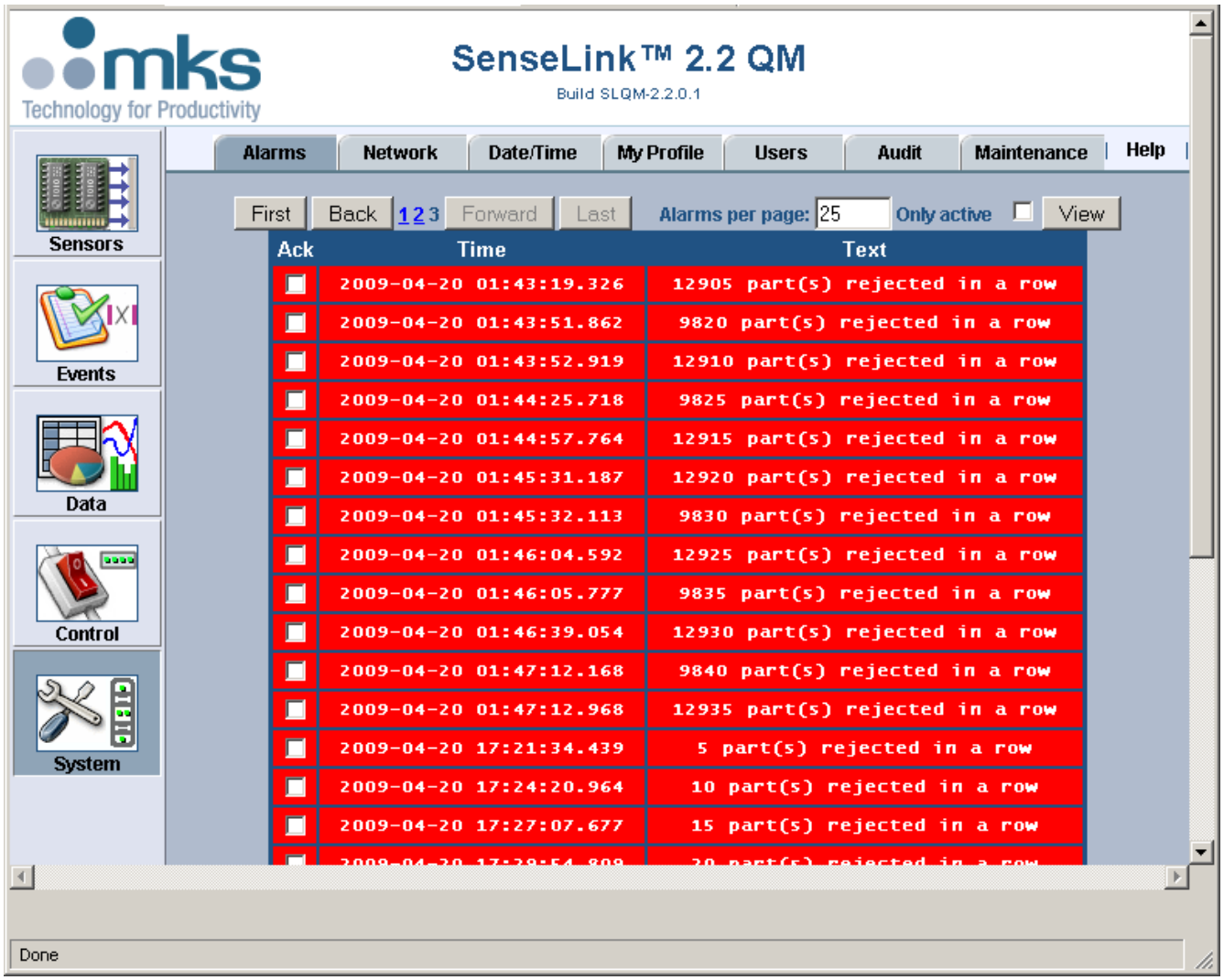


Figure 120 System Main Tab/Alarms Tab

6.5.2 Network

You can change the IP-Address, Subnet mask and Default Gateway via the user interface.
Changes to the setup will become active after a reboot of the SenseLink™ or after you tested the new settings successfully and confirmed the changes.

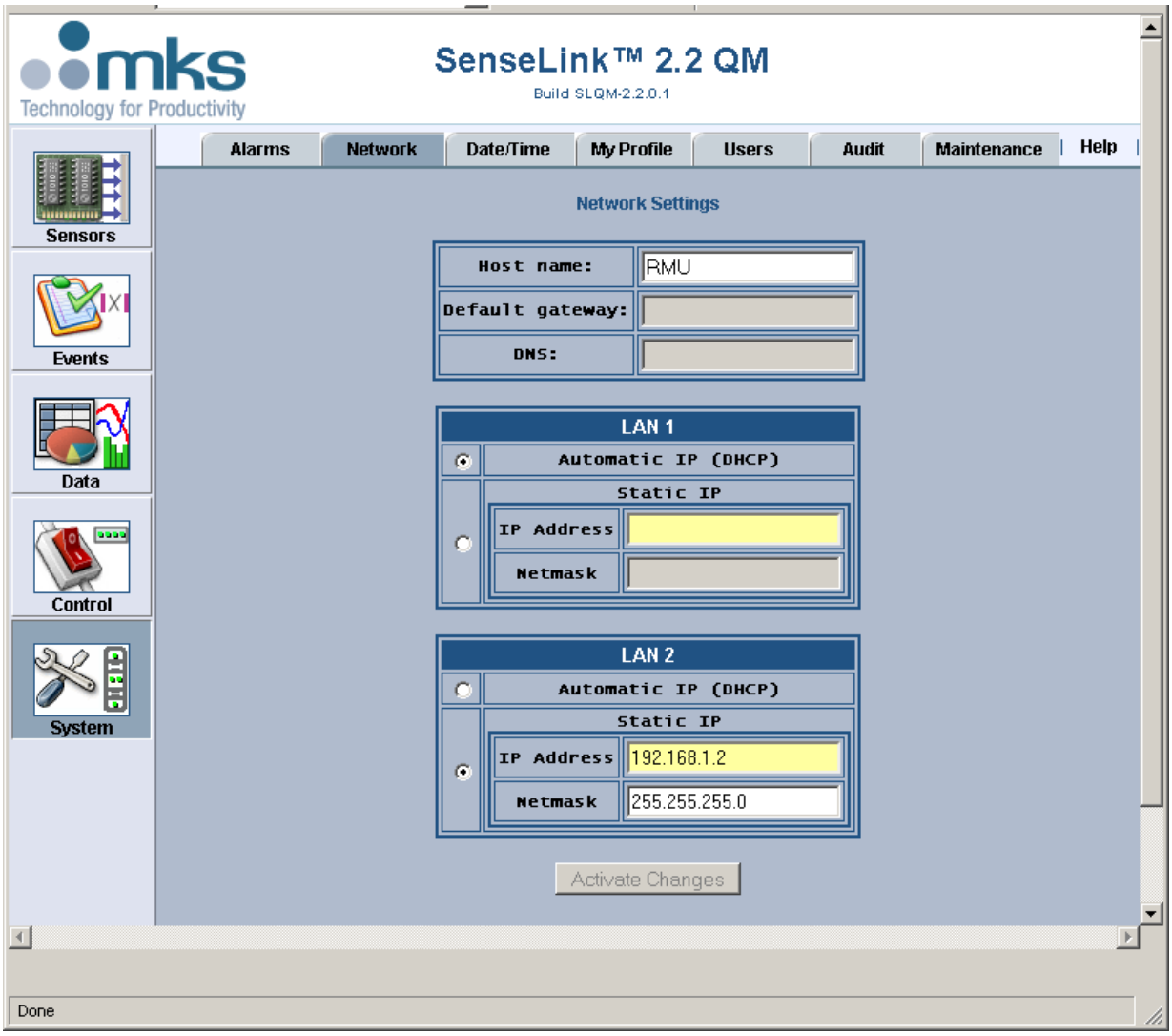


Figure 121 Network Tab

6.5.3 Date/Time

The date/time tab allows users to set the time zone and the time of the system. Select ***Activate Changes*** when the time is entered.

Figure 122 Data Time Tab

6.5.4 My Profile

To change a user's password select the ***My Profile*** tab and enter in the old password along with the new one entered twice. Also the homepage of the SenseLink, when that user logs in, can be changed here. Select the drop down arrow and select any of the pages to be the home page.

Figure 123 Editing SenseLink Password and Profile

6.5.5 Users

Selecting the ***Users*** tab will allow the administrator to add users to the system and to edit the access rights of the user. Select ***Edit*** under Access rights and allow full access, read-only, or no access to each of the users.

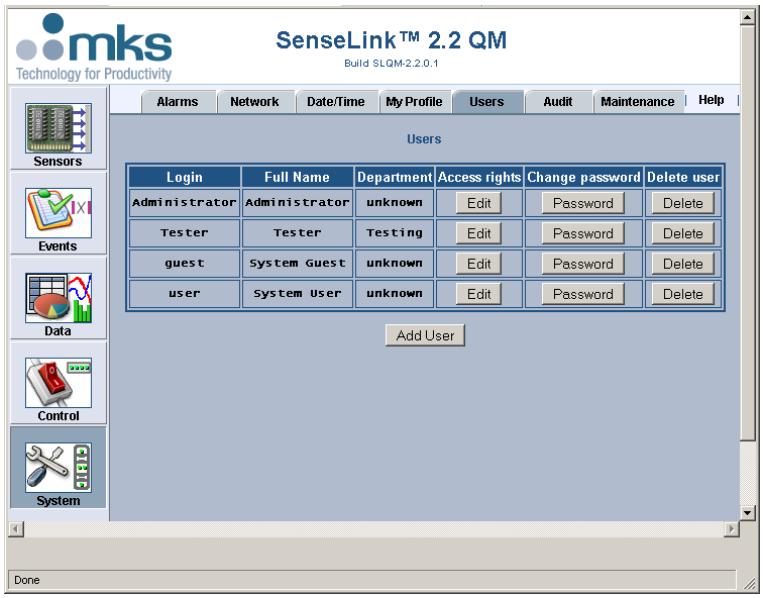


Figure 124 Editing Users of the SenseLink

6.5.6 Audit

The Audit tab allows users to see all of the changes that have been made in the SenseLink and who has made them. Changing the number of Records per page will allow the user to view past changes.

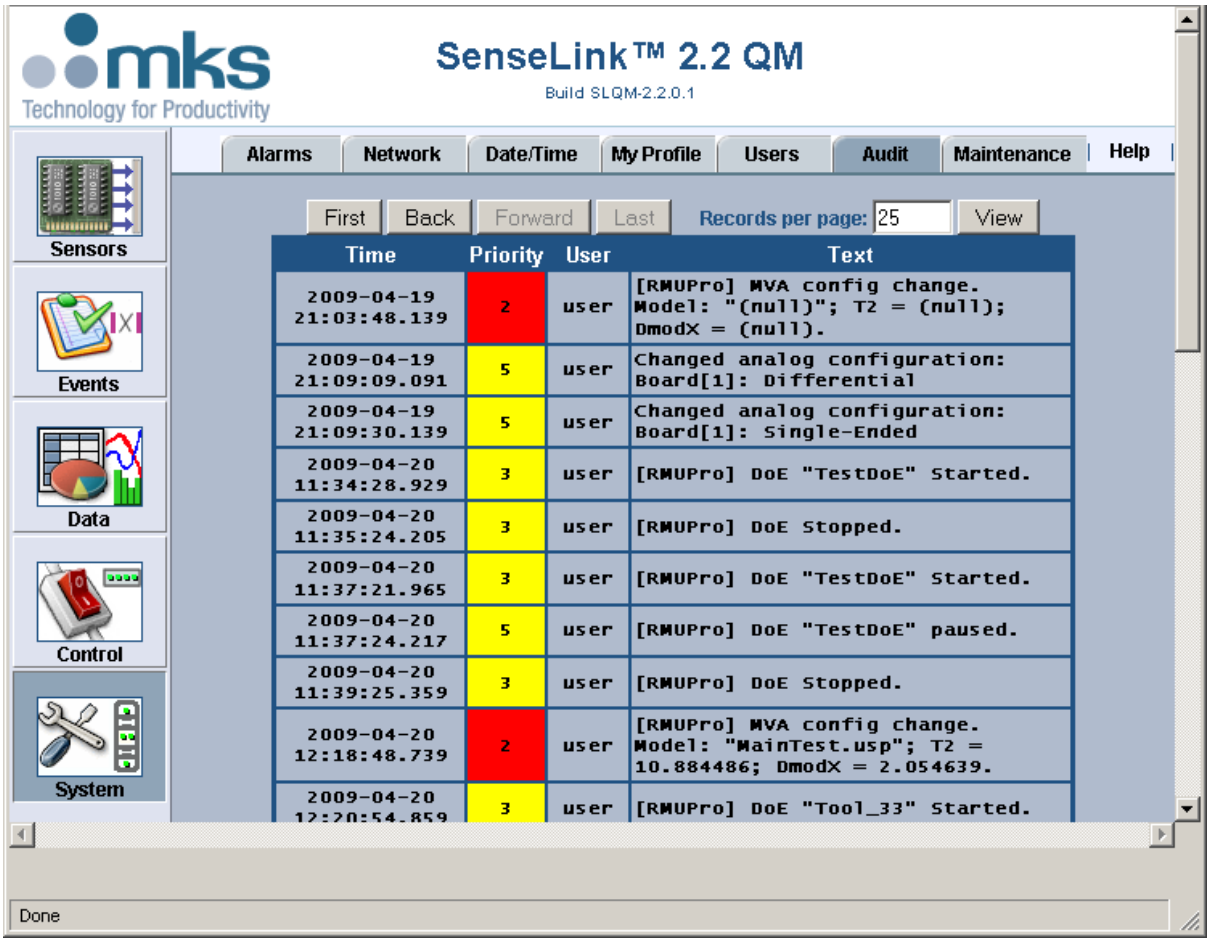


Figure 125 Audit Tab

6.5.7 Maintenance

The Maintenance tab gives users the ability to perform diagnostics, to export the unit's configuration, to view any other SenseLinks on the network, to edit the emailing of the system, and to update the systems software.

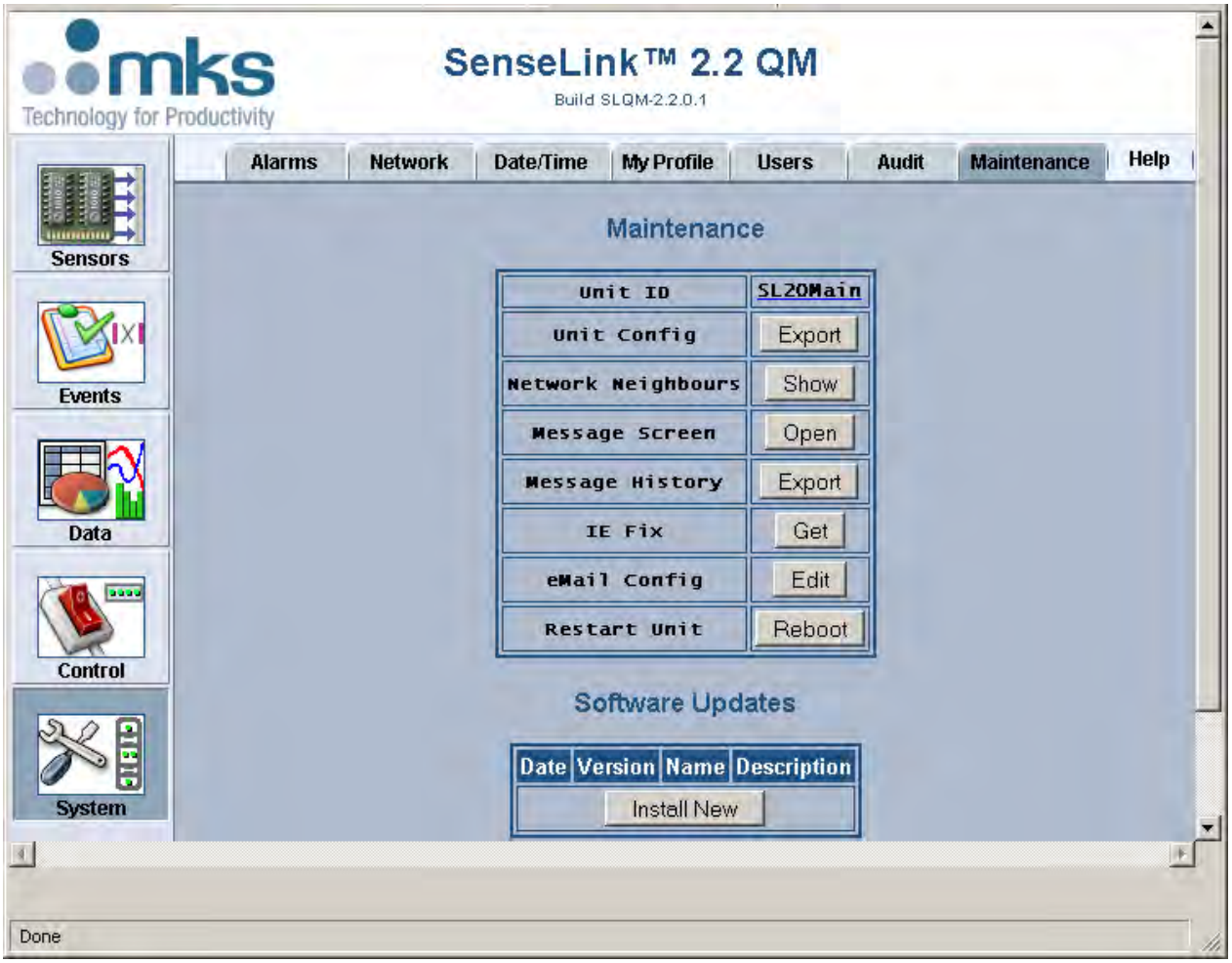


Figure 126 Maintenance Tab

You can perform basic diagnostics by selecting ***Open*** for the Message Screen, displaying debug messages from the web server and analog/digital driver. The SenseLink™ QM does not support local storage of diagnostic log files.

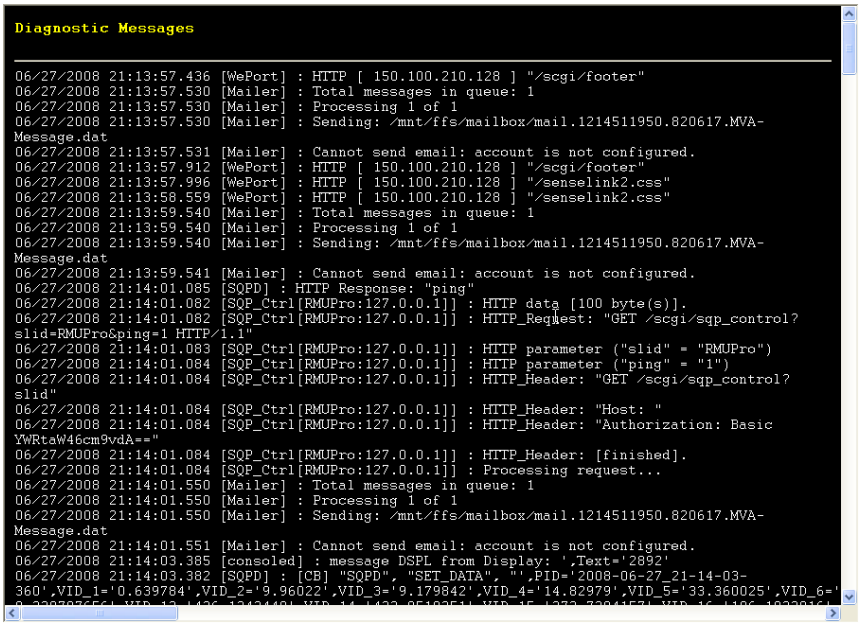


Figure 127 Diagnostic Monitor

The following steps are required to update the SenseLink™ QM software:

- Click on ***Install New*** in the SenseLink™ System/Maintenance Menu at the bottom of the page.
- A new window will pop up. Click ***Next***.
- ***Browse*** for the update package and click ***Next***.

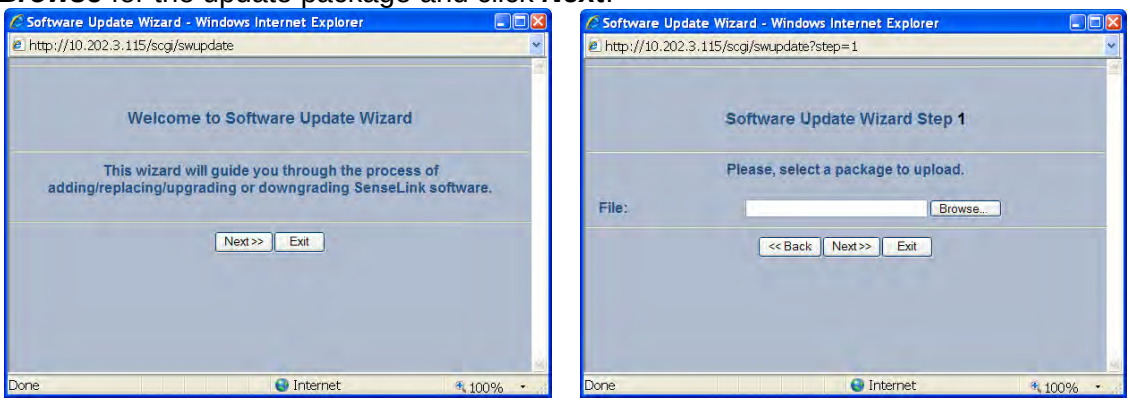


Figure 128 Updating Software

- The SenseLink™ will upload the package and start the installation once you select ***Install*** on the screen below.
- The system will reboot and the changes will take place.

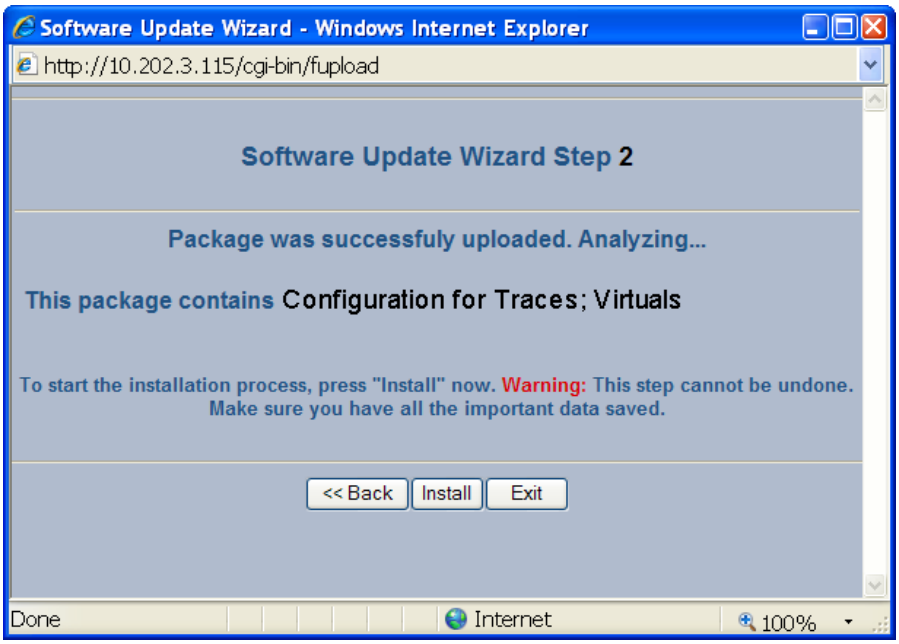


Figure 129 Installing a Packaged Configuration File

7 Data Features (Virtuals)

Data features are calculated, from the raw data, to more efficiently describe the injection molding process and to provide valuable process outputs to the user. A specific set of data features will initially be created in the SenseLink based on the available process signals. The data features that are used were chosen because they are directly related to the process signals being monitored and they have been proven to be indicative of part quality and material behavior. Any further data features can easily be added by the user.

Some examples of data features and how they are calculated can be seen below (The event name is used in these equations, but the event number is currently used in the calculations):

Description=F_Time
Expression=timeof(F_Start, F_End, 0)

F_Time represents the fill time, and the time is calculated from the moment the filling digital signal turns on to when it turns off. The zero at the end of the formula tells the SenseLink to keep this value to the end of the cycle and to reset it when the next filling digital signal turns on during the next shot.

Description=Cyc_Time
Expression=timeof(Cyc_Start, 0, Cyc_End)

Cyc_Time represents the cycle time, and the zero in the middle of the formula tells SenseLink to reset the value to zero at cycle end which is actually the beginning of the next cycle. NOTE: if the start and

stop event occur at the same time or event, the “0” argument should be placed in between the events as opposed to at the end of the equation.

Description=Sdis_F
Expression=maxin(AI1_6, F_Start, F_End, 0) – minin(AI1_2, F_Start, F_End, 0)

Sdis_F represents the screw displacement during the filling stage. This is calculated by taking the maximum of the screw position (AI1_6) from fill start to fill end minus the minimum of the screw position from fill start and fill end; the value is then reset when the digital filling signal turns on again.

Description=Int_InjP_F
Expression=integral(AI1_5, time, F_Start, F_End, 0)

Int_InjP_F represents the integral of the injection pressure during the filling stage. This is calculated by taking the area under the curve or the integral of the injection pressure (AI1_5) with respect to time from fill start to end.

The table below lists the supported operators.

Table 23 Supported Operators

Expression	Description
+	Indicates addition operation
-	Indicates subtraction operation
/	Division operator
*	Multiply operator
Avgof(Ch. Name, from, to, 0)	Average operator
Drvin(Ch. Name, w/respect to Ch. Name, percent of stage, from, to)	Derivative operator
=	Equality operator
!=	Inverse equality operator
>	Logical compare Greater than
>=	Logical compare Greater than or Equal to
<	Logical compare Less than
<=	Logical compare Greater than
()	Parenthesis for defining or modifying order of operation
&	Logical And
!	Logical Not
^	Order of magnitude
Or	Logical Or
Xor	Logical exclusive Or
Avg(Ch. Name, # of samples to avg)	Performs a moving average or filter of the input channel
Minin(Ch. Name, from, to, 0)	Min input value *Cannot be reset without control function
Maxin(Ch. Name, from, to, 0)	Max input value *Cannot be reset without control function
Timeof(Ch. Name, from, to, 0)	Timeof input value *Cannot be reset without control function
Integral(Ch. Name, w/respect to Ch. Name, from, to, 0)	Integral Operator

A list of the default data features created from the standard signals is shown below.

Table 24 Standard Data Feature List

Standard SenseLink QM Data Features/Virtuals		
Num	**Name**	**Description**
1	Fill Time	Time of mold filling phase
2	Pack Time	Time of mold packing phase
3	Recovery Time	Time of screw recovery
4	Cool Time	Time of mold cooling
5	Cycle Time	Time of process cycle – mold open to mold open
6	Sdis_Fill	Screw displacement during filling stage
7	Sdis_Pack	Screw displacement during packing stage
8	Sdis_Recovery	Screw displacement during plastication stage
9	Injection Velocity	Average screw velocity during filling stage
10	Velocity at Transfer	Average screw velocity at VP transfer
11	Velocity during Pack	Average screw velocity during packing stage
12	Velocity during Recovery	Average screw velocity during screw recovery
13	Max Fill Pressure	Maximum injection pressure during filling stage
14	Avg Fill Pressure	Average injection pressure during filling stage
15	Pack Pressure	Average injection pressure during packing stage
16	Back Pressure	Average injection pressure during screw recovery
17	Injection Energy	Total injection energy measured during the filling and packing stages
18	Recovery Energy	Total plastication energy measured during the plasticating stage
19	Melt Visc during Fill	Measure of average viscosity of material during filling
20	Melt Visc during Recovery	Measure of average viscosity of material during plastication
21	Max Nozzle Temp	Maximum nozzle temp
22	Min Nozzle Temp	Minimum nozzle temp
23	Avg Nozzle Temp	Average nozzle temp
24	Avg Zone 1 Temp	Average zone temp 1
25	Avg Zone 2 Temp	Average zone temp 2
26	Avg Zone 3 Temp	Average zone temp 3
27	Integral of Fill Pressure	Integral of injection pressure during filling stage
28	Integral of Pack Pressure	Integral of injection pressure during packing stage
29	Integral of Back Pressure	Integral of injection pressure during plastication
30	Cushion	Minimum screw position at end of packing stage
31	Shot Size	Maximum screw position at start of filling stage

Some additional virtuals can be added as new inputs or signals are added to the system.

Table 25 - Some Additional Data Features

Additional SenseLink QM Data Features/Virtuals		
Num	**Name**	**Description**
38	Integral Clamp Force	Integral of the clamp force during mold close
39	Avg Screw RPM	Average screw RPM during plastication stage
40	Peak Cavity Pressure	Maximum cavity pressure
41	Integral Cavity Pressure	Integral of cavity pressure
42	Cavity Pressure Slope	Cavity pressure slope after peak
43	Peak Cavity Temp	Maximum cavity temperature
44	Integral Cavity Temp	Integral of cavity temperature
45	Cavity Temp Slop	Cavity temperature slope after peak
46	Avg Hot Runner Temp	Average hot runner temperature
47	Max Hot Runner Temp	Maximum hot runner temperature
48	Max Coolant Temp	Maximum coolant temperature
49	Integral Coolant Temp	Integral of coolant temperature

8 Dual MVA Station

The standard SenseLink QM comes as a single MVA station, meaning it can run one multivariate model at a time, but a dual MVA stationed SenseLink QM can also be used depending on the application and process. The dual MVA station is generally need for processes which have two different and consecutive process steps. The dual station SenseLink QM comes just as a standard SenseLink QM package but has additional viewing and analysis pages for the 2nd model.

Notice in the figure below, there are additional tabs for MVA Config and MVA DoE to allow the user to create and activate a 2nd model, which can run simultaneously with the first model.

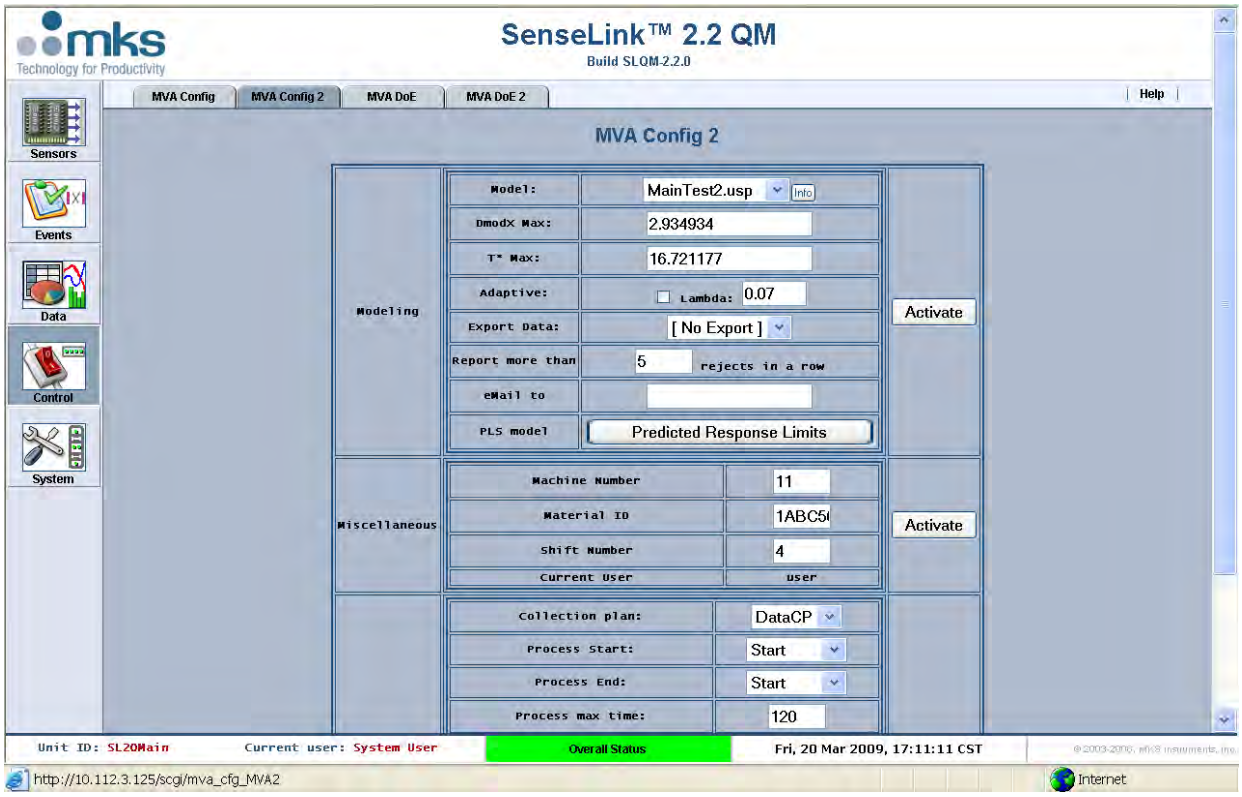


Figure 130 - Configuring Model for Dual MVA

Once the 2nd model is activated, there are also additional tabs to allow the user to view both models. Note that there is an additional tab for MVA, PLS, and MVA Report to provide the analysis for both models.

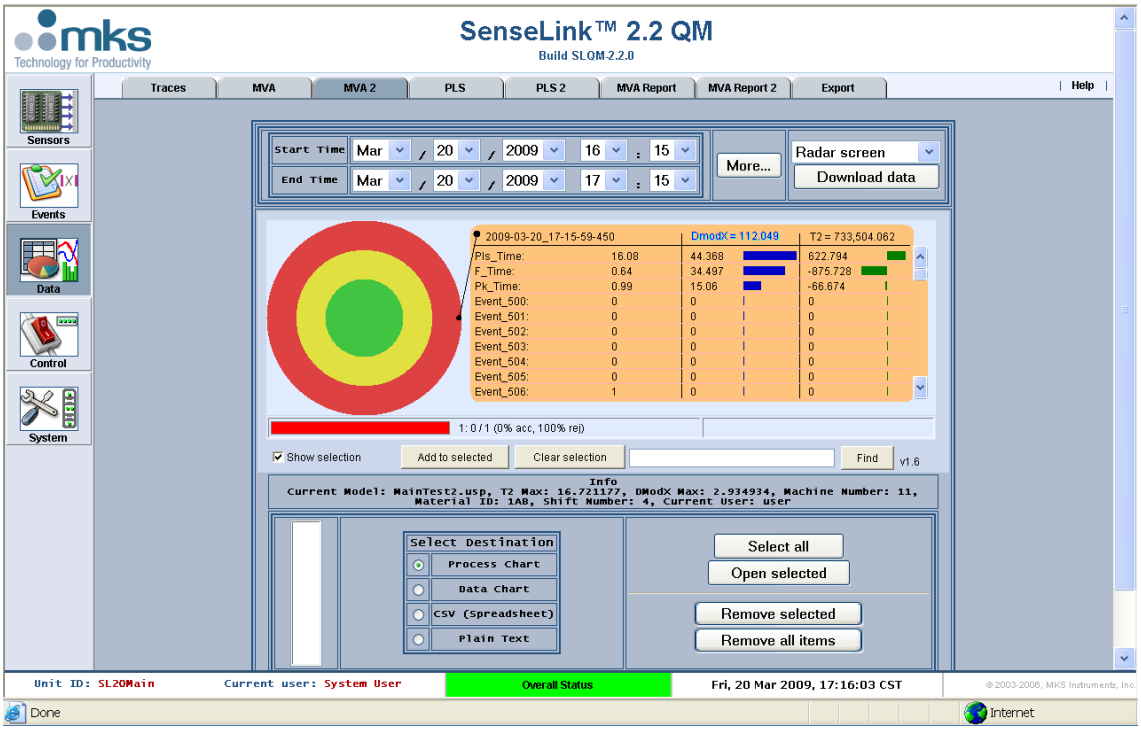


Figure 131 - Viewing Data from Dual MVA Station

9 Appendix

A typical first installation may consist of the following major elements to ease installation:

Table 26 Example SenseLink Hardware Installation

Item	Description	MFG P/N	MKS P/N		Manufacturer	Qty
1	Power supply	8708660000	PS10004	Power supply, 100-240VAC to 24VDC (3A)	Weidmuller	1
2	SenseLink QM	AS00935-07	AS00935-07	RMU2-D-DIDO-AH	MKS	1
3	CompactFlash	SDCFH-1024-388	AR00071	CompactFlash, 4G	Sandisk	1
4	Thermocouple Input module	8560720000	SW10009	Type J, K, T, E, N, R, S, B configurable	Weidmuller	4
5	Terminal block	AR10157	AR10157	Terminal block, 37Dsub Female	Weidmuller	2
6	I/O cable	WA10023	WA10023	Cable, Dsub37MF, 2.5ft	L-com	2
7	DIN Rail	BAA1000-x		DIN rail, x " length (30")	Idec	1

Physical dimensions are 30" long x 5" high x 5" deep.

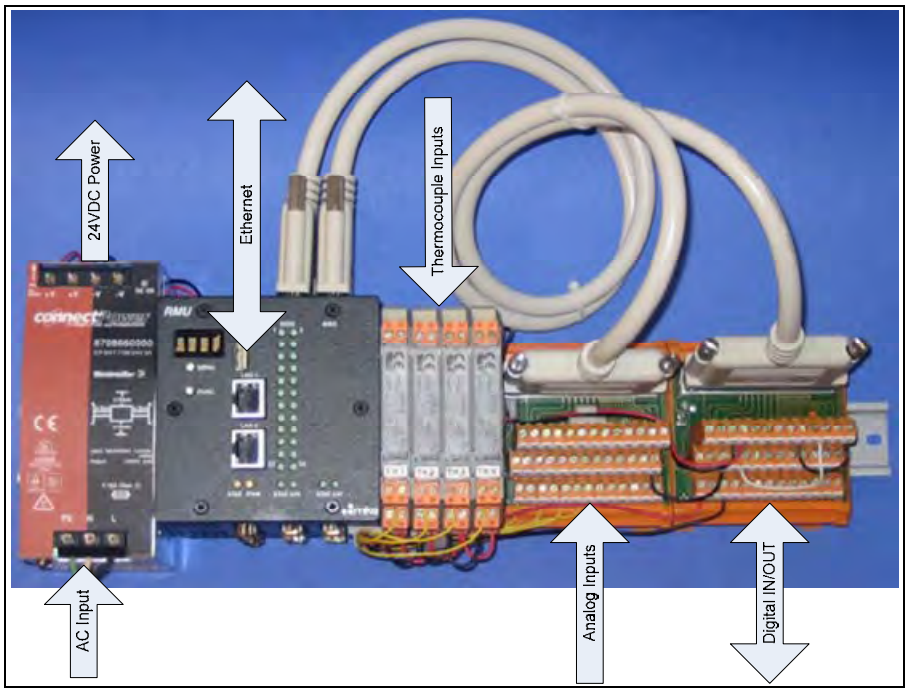


Figure 132 Hardware Installation

10 Model Code Description

The Model code of SenseLink QM defines the features of the Unit for Hardware, software and other options:

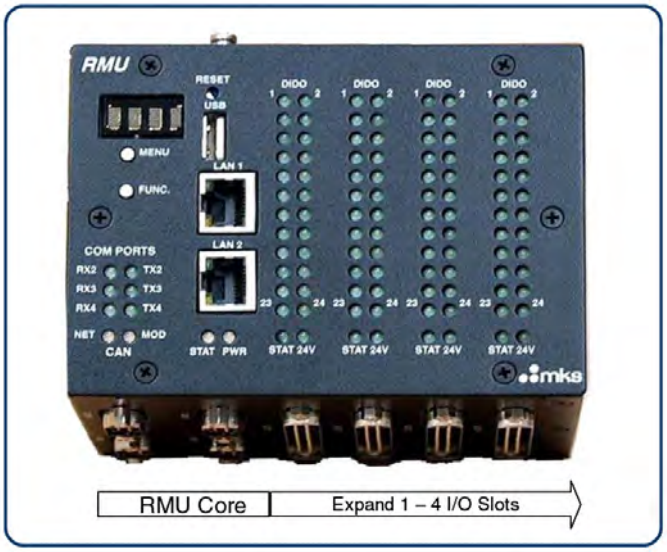
	BASE		OPTIONS		SLOT 1		SLOT 2		SLOT 3		SLOT 4
Format:	**RMU2**	**-**	**C**	**-**	**DIDO**	**-**	**DIDO**	**-**	**DIDO**	**-**	**DIDO**
			D		AIAO		AIAO		AIAO		AIAO
			CF		AHAO		AHAO		AHAO		AHAO
					ACAO		ACAO		ACAO		ACAO
					COMB		COMB		COMB		COMB

Options

-C	With CAN and (2) additional RS232/485 ports
-D	With Display and Function Keys
-CF	CompactFlash, range 64MB to 8GB

Slot Designations

-DIDO	24 Channel Digital I/O Card
-AIAO	16SE/8DIFF Analog In, 8SE Analog Out
-AHAO	16SE/8DIFF Analog Inputs (1M ohm), 8SE Analog Out
-ACAO	8DIFF Analog Inputs (Current Type Inputs), 8SE Analog Out
-COMB	Combination: 16DIDO, 4AI-DIF, 2AO-DIF



11 Specifications

Physical Specifications

Criteria	Specifications
Dimensions	4” H x 4” W x 2”D plus 0.8” per I/O slot
I/O Connectors	37-pin male D-sub
Ethernet Connector	100 BaseT, RJ45 with EMI filter,LED indicators
RS-232 Connector	DB9 male connector
Weight	600g (1.32 lb)

Environmental Specifications

Criteria	Specifications
Operating Temperature	0 to +55°C
Storage	-40 to +85 °C
Humidity	5 to 95% non-condensing

RMU Core - Functional Specifications

Criteria	Specifications
PowerPC 5200	400 MHz, 760 MIPS with support of floating point instructions
On board Flash	16 MB
SDRAM	128 MB
Real Time Clock	Battery backed, lithium ion
CompactFlash Port	Type I,II
Ethernet Ports	(2) 10/100 independent Ethernet controllers
Serial Ports	(4) Total. (2)RS232 and (2) RS232/485 software selectable.
BUS Interface	2 isolated Ethernet ports – Modbus/TCP or Ethernet/IP
CAN Port	DB9 Connector, Isolated CAN2.0 port.
USB	USB V1.1 compliant
Front Panel Indicators	Network Status, Module Status, LINK, 100MB
Rotary Switches	IP address, operating mode

Power Specifications

Criteria	Specifications
DC Input	18 – 30 VDC Powered from pluggable 5.0mm connector 10 W for RMU Core (500mA at 24VDC) 5-17 W per I/O card
Certifications	CE pending

Input/Output Specifications per Card

Criteria	Specifications
DIDO Card	
Number of Digital I/O	24 points (input or output)
Power	Requires 24VDC +/-10% for each card
Polarity	Active High/Low selectable for each set of 12 I/O via connector jumper
Response Time	50µsec for DI to interrupt
Digital Input	Minimum current of 0.5mA turn-on
Current sinking	0-5V ON
Current sourcing	18-24V ON
Digital Output	
Current sinking	Active low, 200 mA max / channel
Current sourcing	Active high, 200 mA max / channel
Current max	750 mA per 6 DO
AIAO Card	
Power	Internal +/-15VDC for analog reference, 1W
Accuracy	0.1% Full scale (-10V to 10V)
Ripple	+/- 5mV
Analog Response Time	200 µsec
Analog Input	16 single-ended points or 8 differential points (s/w selectable)
Resolution	14 bit
Hardware Filter	1Khz RC filter (specials available on request)
Voltage Range	-10V to 10V
Current Range	0 to 20mA with 250ohm input impedance
Analog Output	8 single-ended points
Resolution	12 bit
Voltage Range	–10 to +10V
Capacity	5mA / channel into a 2 KΩ load
COMBO Card	
Digital I/O	16 points (input or output)
Analog Inputs	4 AI, Differential Voltage
Analog Outputs	2AO, Differential Voltage
Power	Requires 24VDC +/-10% for each card
NOTE:	For all other COMB card specifications, see above DIDO and AIAO cards

WARRANTY

MKS Instruments, Inc. (**MKS**) warrants that for one year from the date of shipment the equipment described above (the "equipment") manufactured by **MKS** shall be free from defects in materials and workmanship and will correctly perform all date-related operations, including without limitation accepting data entry, sequencing, sorting, comparing, and reporting, regardless of the date the operation is performed or the date involved in the operation, provided that, if the equipment exchanges data or is otherwise used with equipment, software, or other products of others, such products of others themselves correctly perform all date-related operations and store and transmit dates and date-related data in a format compatible with **MKS** equipment. THIS WARRANTY IS **MKS'** SOLE WARRANTY CONCERNING DATE-RELATED OPERATIONS.

For the period commencing with the date of shipment of this equipment and ending one year later, **MKS** will, at its option, either repair or replace any part which is defective in materials or workmanship or with respect to the date-related operations warranty without charge to the purchaser. The foregoing shall constitute the exclusive and sole remedy of the purchaser for any breach by **MKS** of this warranty.

The purchaser, before returning any equipment covered by this warranty, which is asserted to be defective by the purchaser, shall make specific written arrangements with respect to the responsibility for shipping the equipment and handling any other incidental charges with the **MKS** sales representative or distributor from which the equipment was purchased or, in the case of a direct purchase from **MKS**, with the **MKS-CIT** home office in San Jose, CA. This warranty does not apply to any equipment, which has not been installed and used in accordance with the specifications recommended by **MKS** for the proper and normal use of the equipment. **MKS** shall not be liable under any circumstances for indirect, special, consequential, or incidental damages in connection with, or arising out of, the sale, performance, or use of the equipment covered by this warranty.

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